DOCUMENT RESUME

ED 152 490 SE 023 366

AUTHOR Fowler, K. E. H.
TITLE Water Pollution: Part I, Municipal Wastewaters; Part II, Industrial Wastewaters.
INSTITUTION Environmental Protection Agency, Washington, D.C. Div. of Manpower Training.
PUB DATE Feb 76
NOTE 190p.; Contains occasional light type

EDRS PRICE MF-$0.83 HC-$10.03 Plus Postage.
DESCRIPTORS *Annotated Bibliographies; Health; Pollution; Reference Materials; *Resource Materials; *Waste Disposal; *Water Pollution Control; Water Resources
IDENTIFIERS *Waste Water Treatment

ABSTRACT

This publication is an annotated bibliography of municipal and industrial wastewater literature. This publication consists of two parts plus appendices. Part one is entitled Municipal Wastewaters and includes publications in such areas as health effects of polluted waters, federal policy and legislation, biology and chemistry of polluted water, municipal wastewater treatment, recycling and reuse of municipal wastewater and eutrophication. Part two is entitled Industrial Wastewaters and includes publications in such areas as major industrial uses of water, water for power and energy, production of paper and allied products, agriculture, and oil spills. For each entry, in both parts, author, publisher, point of view, level, and summary are given. Appendix A is a continuation of the bibliography into suggested student readings on wastewater management. Appendix B is a regular bibliography of textbooks and handbooks on wastewater management. Appendix C discusses the availability of relevant government reports. (HB)

**********
* Reproductions supplied by EDRS are the best that can be made *
* from the original document. *
**********

ED152490

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
NATIONAL INSTITUTE OF EDUCATION

THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL NATIONAL INSTITUTE OF EDUCATION POSITION OR POLICY

"PERMISSION TO REPRODUCE THIS MATERIAL HAS BEEN GRANTED BY

Bernard Lukco

TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) AND USERS OF THE ERIC SYSTEM."

# WATER POLLUTION

## Part I, Municipal Wastewaters

## Part II, Industrial Wastewaters

K. E. M. Fowler

February, 1976

An annotated bibliography prepared under contract to the U. S. Environmental Protection Agency, Academic Training Section, Water Quality Control, Manpower Training Branch. John M. Fowler, Project Director.

SE 023 266

CONTENTS


| | | Page |
|---|---|---|
| Preface | | i |
| Review Paper: "The Water Environment" | | (95-162) |
| Part I: Municipal Wastewaters | | |
| I. | Basic General References | 1 |
| II. | Health Effects of Polluted Waters | 16 |
| III. | Federal Policy and Legislation | 26 |
| IV. | Biology and Chemistry of Polluted Water | 45 |
| V. | Municipal Wastewater: Collection and Transportation | 54 |
| VI. | Municipal Wastewater Treatment | 62 |
| VII. | Disposal and Utilization of Wastewater Treatment Sludges | 70 |
| VIII. | Recycling and Reuse of Municipal Wastewater | 78 |
| IX. | Economic Aspects of Water Pollution Control | 85 |
| X. | Eutrophication: A Special Case | 103 |
| Part II: Industrial Wastewaters | | |
| I. | Basic General References | |
| II. | Major Industrial Uses of Water | |
| | A. Water for Power and Energy | |
| | B. Production of Paper and Allied Products | |
| | C. Steel, Chemical and Petroleum Industries | |
| | D. Agriculture | |
| | E. Other Industries | |
| III. | Oil Spills: A Special Case | |
| Appendix A: Suggested Student Readings | | |
| Appendix B: List of Textbooks and Handbooks | | |
| Appendix C: Availability of Government Documents | | |

# WATER POLLUTION

## Part I, Municipal Wastewaters

I. BASIC GENERAL REFERENCES

1. CLEAN WATER FOR THE 1970'S

Author: Federal Water Quality Administration, U. S. Department of the Interior.

Publisher: NTIS #PB 217 832 (221 pp.; $6.00) April 1970.

Point of View: "The purpose of this first annual progress report is to provide a groundwork for understanding the nature of the Federal and State water pollution control programs, to detail the progress which has been made during the first year of the Nixon Administration, and to assess the measures which will be required to fulfill the challenge of the 1970's."

Level: Non-technical.

Summary: With the passage of the Water Quality Improvement Act of 1970, the Federal Water Pollution Control Administration took on a new name, becoming the Federal Water Quality Administration (FWQA), and began the task of assessing the progress and capabilities of the Federal water pollution control program. This report is the product of that evaluative effort and it provides both a good summary of the evolution of the Federal water pollution control program and an outline of the direction in which the Nixon administration sought to move the agency through various program and legislative efforts. As the first summary report of that reorganization, it is a valuable basic reference in the literature of water pollution.

In the introductory section of the report "Water Pollution and the Environment", the author's provide a very readable summary of the sources and dimensions of the water pollution problem. Separate sections are addressed to each of the major categories of water wastes: Municipal Wastes, Industrial Wastes, Thermal Pollution, Oil and Hazardous Substances, Mine Drainage, Sedimentation and Erosion, Feedlot Pollution, Other Agricultural Wastes, and Wastes from Watercraft. Although necessarily brief, these sections do

Basic General References cont'd.

provide useful descriptions of the kinds of effluents involved and their impact on the nation's water supplies. There is very little in the way of specifics or hard data, but a good sense of the scope of the national water pollution problem is conveyed.

The remaining sections of the report are addressed to potential solutions to the problem. "A Water Pollution Control Program for the 1970's" contains an examination of the strategy behind the Administration's proposals and identifies five areas of concentration: Financing of municipal treatment, standards and enforcement authority, assistance to the states, programs for dealing with pollution from Federal activities, and programs to deal with emerging problems.

Some of the most valuable and enlightening material in the report is contained in the "Programs for Water Pollution Control" section which follows. It is essentially a review of the strengths and shortcomings of existing regulatory, assistance, planning, and research, development, and demonstration programs. Specific areas under each program category are concisely reviewed, providing an excellent single-source reference on the scope and quality of the water pollution control program efforts at the Federal level. It is the most detailed treatment provided in the report and points to the kinds of problems involved in trying to monitor production and dissemination of pollutants. The closing page in this section, titled "The Human Element", looks briefly into the areas of public information and education, youth programs, and the general issues which impact on training and manpower development. The final section, "Organization, Resources and Facilities" is simply an outline of the structure and budget of the Federal Water Quality Administration. The most obvious element here is the four-fold increase in monies relegated through the FWQA for construction grants for waste treatment works, a strategy in keeping with the overall direction

Basic General References cont'd.

of the proposed program efforts which emphasize the responsibilities of the states and local communities.

Essentially then, this is the planning document for the Nixon Administration's initiatives in the area of water pollution control. It provides both a definitive guide to program strategies at the Federal level and a useful, readable summary of the magnitude of the water pollution problem.

2. WATER QUALITY CRITERIA 1972

Author: A report of the Committee on Water Quality Criteria, Environmental Studies Board, National Academy of Sciences, National Academy of Engineering.

Publisher: USGPO, Washington, D. C. (594 pp.; $12.50; Stock #5501-00520) 1972 (Prepared under USEPA Contract R3-73-033).

Point of View: "Social perspectives and policies for managing, enhancing, and preserving water resources are undergoing rapid and pervasive change. Because of the stipulations of the 1965 Water Quality Act, interstate water resources are currently categorized by use designation, and standards to protect those uses are developed from criteria. It is in this context that the Report of the NAS-NAF Committee, like that of the NTAC, was prepared . Concepts of managing water resources are subject to social, economic, and political decisions and will continue to evolve; but the Committee believes that the criteria and recommendations in this Report will be of value in the context of future as well as current approaches that might be taken to preserve and enhance the quality of the nation's water resources."

Level: Semi-technical; illustrated; numerous figures; bibliography.

Basic General References (cont'd).

Summary: Intended originally as an updating of the 1968 NAS report, "Water Quality Criteria", the 1972 report evolved into a much more comprehensive document. It is the product of six Committee Panels: (1) Recreation and Aesthetics, (2) Public Water Supplies, (3) Freshwater Aquatic Life and Wildlife, (4) Marine Aquatic Life and Wildlife, (5) Agricultural Use of Water, (6) Industrial Water Supplies. In addition, the individual panels had access to a broad array of special advisors on specific water quality concerns and to the professional staff of the EPA. What emerged from all this is described in the report preface as follows:

> The 1972 Report is vastly more than a revision of the NATAC Report. To begin with, it is nearly four times longer. Many new subjects are discussed in detail, among them: the recreational impact of boating, levels of use, disease vectors, nuisance organisms, and aquatic vascular plants; viruses in relation to public water supplies; effects of total dissolved gases on aquatic life; guidelines for toxicological research on pesticides and uses of toxicants in fisheries management; disposal of solid wastes in the ocean; use of waste water for irrigation; and industrial water treatment processes and resultant wastes. Many toxic or potentially toxic substances not considered by the NTAC are discussed including poly-chlorinated biphenyls, phthalate esters, nitrilotriacetate (NTA), numerous metals, and chlorine. The additional length also reflects the greater current awareness of how various characteristics of water affect its quality and use; and

Basic General References (cont'd.)

the expansion of the information base of the NTAC Report through new data from recent research activities and the greater capabilities of information processing, storage, and retrieval -- especially evident in the three appendixes -- have made their impact on the increase in size.

In short, this is an excellent overview document on all facets of water quality, and is an especially useful companion to the more qualitative "Clean Water for the 1970's" (Ref. I-1). Particularly useful summaries are included on water monitoring techniques and findings, the nature and detection of toxic materials, categories of pollutants in fresh and marine waters, the effects of harmful substances on wildlife, and the major uses and treatment processes associated with industrial water supplies. Additional data on three areas is provided in the appendices: Recreation and Aesthetics, Freshwater Aquatic Life and Wildlife, Marine Aquatic Life and Wildlife. Also included is a glossary of terms, a section on conversion factors, biographical notes on the panel members, and author and subject indices.

3. CLEAN WATER - REPORT TO CONGRESS, 1973

Author: U. S. Environmental Protection Agency

Publisher: USGPO, Washington, D. C. (52 pp. plus appendices: Report EP.43) May 1973.

Point of View: This is the first of a series of annual reports from the EPA required under the provisions of the Federal Water Pollution Control Act as a means of informing Congress of the "measures taken to implement the objectives of the Act."

Basic General References (cont'd)

Level: Non-technical; illustrated; several tables.

Summary: Essentially, this report is aimed at providing a summary of two important aspects of the water pollution issue: where we are now and how we got here. It begins by outlining the provisions of the six legislative enactments that, since 1948, have determined the direction and scope of the federal water quality program. Brief paragraphs are addressed to each of the separate legislative efforts: the 1948 Act, the 1956 Act, the 1961, 1965, 1966 and 1970 Amendments, and the "most extensive and far-reaching" Amendments of all, those of 1972. These latter Amendments are given fairly detailed explanation here in terms of their authority regarding pollutants from industrial and municipal sources, and from nonpoint sources, and their provision for water quality standards, permits and licenses, and enforcement.

The eight chapters which follow this introductory discussion deal in four or five pages each with the following topics: Water Quality Planning and Surveillance, Water Quality Research, Development of Industrial Effluent Limitations, Federal Enforcement, State and Local Water Pollution Control Programs, Efficiency of Treatment Works, Manpower Programs, and the Water Pollution Control Advisory Board. Obviously so brief a treatment is necessarily incomplete, but the major points are brought into each discussion and some useful, recent data is displayed in the various tables.

Appended to the report is a series of tables which show the legal actions taken by EPA under the provisions of the 1972 legislation. These include water quality standards violation notices, enforcement conference-type actions, civil cases referred to the Justice Department, and criminal cases referred to the Justice Department. Finally, a five-page appendix

provides a collection of "Recommendations of the Water Pollution Control Advisory Board". These are directed specifically to three areas of concern: animal wastes, land use, and ocean disposal. In short, this is a good, quick summary of what the Federal government has authority to do in the area of water pollution and what, in actuality, it has been doing since 1972.

4. URBAN PLANNING ASPECTS OF WATER POLLUTION CONTROL

Author: Sigurd Grava, Institute of Urban Environment, Columbia University.

Publisher: Columbia University Press, New York (250 pp.; $10.00) 1969.

Point of View: "The major thrust of [this] study has been to analyze the problem of waste disposal as it imposes a constraint on the policy choices available to the urban planner."

Level: Semi-technical; several graphs and tables; bibliography.

Summary: While this is really a dual-purpose book, aimed on one level at providing the general reader with some background in the technology of water pollution control, its major focus is on the urban planning aspects of water pollution control mechanisms. A very valuable summary of the dimensions of the water problem in this country is provided in three introductory chapters: "Features of the Problem" (water generation and dumping, treatment methods, work with the causes of pollution), "Watershed Systems: Regional Aspects", and "Sources and Types of Pollutants." This latter chapter breifly examines the methodologies involved in the monitoring of water quality, and then examines separately three major contributions to urban wastewater: domestic sewage, commercial and industrial waste, and special pollutants (detergents, street wash-off,

inorganic fertilizer, and thermal pollution). Finally, "Technological Aspects" is addressed to the description of individual systems (septic tanks, etc.), collection networks, treatment facilities and processes, so-called "package plants" (factory-made compact units which are transportable and contain all the necessary equipment for sewage treatment), and the water reuse concept. Obviously, so brief a treatment is necessarily incomplete. Taken together, however, these first four chapters provide a clear and concise introduction to the major aspects of water pollution technology. There are numerous references to additional sources of information on each aspect under discussion and some helpful illustrative material is included.

Chapter 5, "Administrative and Regulatory Aspects", introduces the second major theme of Grava's study and the final four chapters in the book are addressed exclusively to policy and planning issues. Discussion is provided of the setting of purity standards, the drafting of ordinances, federal and state participation in the financial demands of water quality programs, and to a number of issues involved in "local planning aspects". These include the effect of water quality control on community development, professional responsibilities of the urban planner, the study-design-construction sequence, the choice of systems in suburbia, site and size of treatment plants, and community-building significance, a section which deals with the financial and growth burdens which a new sewer system puts on a community. The last chapter in the book, "Problems in Developing Countries", provides a brief sketch of the kinds of collection networks and disposal facilities which are evolving to match the special needs of developing countries. Some useful, though now somewhat dated, information is appended, including a table of sewage generation rates for commercial and public establishments, efficiencies of sewage treatment units, treatment plant construction costs (1964 figures), and a list of "General

Basic General References cont'd.

Criteria for Sewage Collection Networks". A fairly extensive, though again somewhat dated, annotated bibliography is also provided. All in all, this is a very useful introductory volume providing a brief summary of the major concepts involved in water pollution technology and policy. It suffers somewhat from a 1969 publishing date, but the interested reader should have little trouble in finding supplementary sources to update the data.

## 5. WASTE MANAGEMENT AND CONTROL

Author: A report to the Federal Council for Science and Technology prepared by the Committee on Pollution, National Academy of Sciences-National Research Council, under the chairmanship of Athelstan Spilhaus, University of Minnesota.

Publisher: Publication #1400, National Academy of Sciences, National Research Council, Washington, D. C., 1966. Copies are available from: Printing and Publishing Office, National Academy of Sciences, 2101 Constitution Avenue, Washington, D. C. 20418 (257 pp.; $4.95) 1966.

Point of View: "The principal objective of the report is to set forth the nature of the pollution problem - descriptively, qualitatively, and comprehensively - in a useful perspective. It represents an effort to determine areas in which science and technology could effectively assist in reducing and controlling pollution."

Level: Non-technical; several tables and graphs.

Summary: Published in 1966, this report of a two-year study into pollution, its origins, nature, effects, and potential constraints and controls, has become a classic reference in environmental literature. Its emphasis is on the complexity of the interactions among the many forms of man-made pollution. To quote from the foreward to the report:

Basic General References (cont'd.)

> [This report] details the interactions among the forms of pollution generated by man, the interactions between the polluted atmosphere, waters, and soils, which in turn affect living systems - the plants and animals that ingest them - and identifies and traces their origins, their movements, and their places of final deposit. It identifies the geographic, social and economic factors that relate to the problem ... It further identifies a first strategy or framework, and priorities within that framework, that will allow a more coordinated attack and ... more efficient and economical means of dealing with the pollution problem ...

Structurally, the report is divided into two sections: an introductory, summary section section and a series of eight appendices. Within the introductory section, specific attention is directed to four aspects of environmental pollution: The Nature of the Problem (the atmosphere and pollution, water and pollution, land and pollution), Legal, Legislative, and Institutional Problems, Areas of Inadequacy (Technology - known and unknown, constraints on existing technology, research and education), and Possible Improved Approaches (available basic methods, auxiliary techniques, and public policy and institutional arrangements). This section concludes with a detailed list of recommendations put forward by the Committee.

The appendices which follow, and which actually make up the bulk of the report, deal in detail with the science and technology of environmental pollution. While there is some discussion of each of the various major pollutants, water pollution is a primary concern and is given particularly thorough consideration. This is true especially in the first five appendices: Pollution Processes in Ecosystems; Criteria, Instrumentation, and Monitoring; The Transport System; The Residue Situation-Current and Future; and Pollution - Abatement Technology. The two appendices on legislative and public policy issues deal in rather broad-based terms, but water pollution is again specifically considered in the appendix, "A Brief Analysis of Pollution in the Delaware Estuary", which looks separately at the input and effects of municipal and industrial source pollutants.

It is, of course, an injustice to the report to attempt to filter out the material dealing specifically with water pollution. This is an extremely valuable document and one which should be read in its entirety. While undergraduate students might find the appendices to be difficult reading, the initial summary section provides a helpful guide to the report and also presents the Committee's general recommendations as to programs which might be initiated as a first step toward "lowering the barriers that now inhibit the development of needed new technology and more effective and flexible institutional relationships."

In summary, there is a wealth of information here which will provide a good introduction, not only to the problems of water pollution, but to the overall impact of pollution on the ecosystem.

General Basic References (cont'd.)

6. THE NATION'S WATER RESOURCES

Author: United States Water Resources Council.

Publisher: U. S. GPO, Washington, D. C. (approx. 450 pp.; $4.25) 1968.

Point of View: "This first assessment highlights the changing nature of future water problems and the constant need to reorient research programs. Greatly increased recycling and reuse of water will be accompanied by the need for new technology and processes in water treatment and conditioning, and in waste treatment and pollution control ... Much more knowledge is needed to develop optimum institutional arrangements for planning, managing, and financing regional water supplies and for coping with water problems arising from urbanization."

Level: Non-technical; illustrated; numerous graphs and tables.

Summary: The Water Resources Council was established by the Water Resources Planning Act of 1965 and charged with the task of "maintaining a continuing study and preparing periodically an assessment of the adequacy of supplies of water necessary to meet the water requirements in each water management region in the United States and of the national interest therein". This report, which represents the Council's first such assessment, provides an excellent introduction to the major issues in water management. It is well written, thoroughly illustrated, and full of the kind of summary data which enables the general reader to quickly grasp the magnitude and the complexity of water management problems.

The report is divided into seven sections. Part I (which is available from the GPO as a separate publication at $.65) provides an overview description of the nation's water and related land resources in terms of water supply and quality, the role of water and land resources in economic growth, water uses, water management techniques, and the adequacy, by geographic region, of our nation's water resources.

Part 2, "Introduction", simply explains the origins of the Water Resources Council and outlines the purpose and approach of the study which led to this report. In Part 3, "Water and Related Land Resources", the Council provides its finding as to the relationship between economic growth and water use. A fairly detailed description of the water resource is provided and there is a good discussion of the sources of water, the phenomena of evaporation and evapotranspiration, and the meaning of terms such as natural runoff, groundwater, etc. A final, brief section addresses the various methods currently available for increasing the availability of our water supplies.

Part 4 provides a discussion of water uses under seven separate headings: domestic and municipal, industrial, electric power, agricultural, navigation, recreation, and the fish and wildlife uses. While the data here is for 1965, there are projections to 2020 on most of the tables and graphs and a good sense of the scope of our water demands is conveyed. How we allocate resources among these needs is addressed in the next section. "Management of Water and Related Land", and the Council briefly outlines here some of the methods employed to develop water supplies and to transport water to the water user. There are separate chapters within this section on floods and flood damage, water quality, watershed lands, beach, shore and riverbank protection, land

drainage, wilderness and free-flowing rivers, and institutional arrangements by which water policy is implemented.

Finally, Part 6, "Regional Water Supplies and Requirements", provides data and descriptive material on each of the twenty regions designated by the Council for separate study. A brief appendix (Part 7) contains a table of contents, a list of figures, acknowledgements, and additional data to support the text material.

There is much useful data and descriptive material in this report and it serves to provide the reader with an excellent introduction to the basic questions of what water is, where it comes from, how much of it we have, how we use it, how we manage it, and how our resources are distributed across our nation.

7. GLOSSARY: WATER AND WASTEWATER CONTROL ENGINEERING

Author: Joint Editorial Board, American Public Health Association, American Society of Civil Engineers, American Water Works Association, and the Water Pollution Control Federation.

Publisher: American Society of Civil Engineers, (345 E. 47th St., New York 10017) 19

Summary: This is an invaluable sourcebook for anyone new to the terminology of wastewater engineering. Prepared by a joint board of representatives from some of the most prestigious engineering societies in the country, this glossary provides careful, concise definitions of terms regularly used or having special meaning in, water and wastewater engineering. For each term a brief definition is provided together with appropriate cross references. Alternative terms having the same or similar meaning are also included in the explanation and in cases where a term may have

more than one meaning, each is precisely noted. Obviously, not all the terms which appear in the literature of wastewater engineering are defined here, but those most apt to confuse the novice are explained and extensive references to other glossaries are noted for those who desire a more elaborate explanation of the terminology.

## II. Health Effects of Polluted Waters

### 1. WATER, HEALTH AND SOCIETY

Author: 'Selected papers by Abel Wolman, Edited by Gilbert F. White, University of Chicago.

Publisher: Indiana University Press, Bloomington, Indiana (400 pp; $17.50 ) 1969.

Point of View: "It has been more difficult to recognize that engineers in effect define community goals by the way they present projects or establish standards of quality or organize studies and operations. To take these influences into account, is to enlarge the scope of considerations engineers feel obliged to assess. To a remarkable degree the writing of Abel Wolman reflects this broadening stream of thought."

Level: Varies from paper to paper but, for the most part, these are non-technical writing.

Summary: Essentially a tribute to the many environmental engineering contributions made by Abel Wolman over the years, this collection of papers ranges over a broad array of water related topics, from water resources and their management, to problems of radioactive waste, flood protection policy, and the role of the engineer in society. For the most part, however, the focus is on water quality and its health implications.

Beginning with the first paper, "Water Resources: A Report to the National Academy of Sciences", this volume contains reprintings of some of the best known analyses in the water literature. While some of the papers are not directly applicable to the question of health effects from polluted waters, they are uniformly readable, informative, and should prove to be valuable background reading for teachers and practitioners of environmental engineering.

The first of the health-related papers here is a reprinting of a 1918 journal article titled "A Preliminary Analysis of the Degree and Nature of Bacterial Removal in Filtration Plants". This is followed, in order of their writing, by papers on "The Nature and Extent of Radioactive Waste Disposal Problems", "An Inquiry into Standards Proposed for Stream Cleanliness", "Bacterial Standards for Natural Waters", "Concepts of Policy in the Formulation of So-Called Standards of Health and Safety", "Changing Public Health Practices and Problems", "The National Health Program - Present Status", and "Trends and Challenges in Public Health".

Perhaps best know for his contributions to the understanding of chlorine absorption, Wolman has a long list of credits to his name and is considered to have been a leading pioneer in the development of sanitary waste water treatment processes. These papers, tracing his career over nearly fifty years, provide an invaluable record of his contributions to the development of our national water practices and policies, particularly as they relate to safeguarding the public health.

## 2. MICROBIAL ASPECTS OF POLLUTION

Author: Proceedings, edited by G. Sykes and F. A. Skinner, British microbiologists.

Publisher: Academic Press, New York (289 PP; $12.50) 1972.

Point of View: "Pollution is an environmental problem and almost invariably arises from the activities of man. As is common, micro-organisms have their part to play, both advantageously and disadvantageously ...."

Summary: The papers collected here were part of a 1971 Society for Applied Bacteriology Symposium on the "Microbial Aspects of Water Pollution."

Health Effects (cont'd.)

There are sixteen papers in all, each contributed by a recognized expert in the field, and together they provide a fairly wide ranging treatment of the topic. Particular attention is focused in several papers on considerations of the health hazards of pollution, especially in terms of sewage pollution of water supplies and the safe disposal of infected material from laboratories. Also treated here are the problems of water purification, and the disposal of sewage and its effect on rivers and lakes, and special problems associated with industrial products, such as pesticides, herbicides, fungicides, and plastics.

The volume is introduced by J. G. Davis in a paper titled "Microbial Aspects of Pollution: Some General Considerations". For the most part, this is a review of the historical development of pollution studies, and an analysis of the special role played by the microbiologist.

An excellent overview paper follows, "The Health Hazards of Pollution," providing discussion of the assessment of microbial hazards of pollution, diseases due to pollution of drinking water supplies, health hazards associated with the recreational use of water, and the relationship between environmental pollution and food. A more detailed analysis of the health hazards of pollution is provided in the next paper, "Sewage Pollution of Natural Waters", in which J. A. McCoy reviews nuisances and the destruction of aquatic life, pathogens in sewage, bacterial content of crude sewage and sewage effluent, Salmonellae in an estuary, and sewage pollution of sea water. The supply of water, treatment and disposal of waters and studges, and self purification in natural waters, are considered in a related paper, "The Scope of the Water Pollution Problem".

Health Effects (cont'd.)

Four fairly detailed and more tightly focused papers follow: "Microbial Aspects of Pollution in the Food and Diary Industries", "Aerobic Treatment of Agricultural Water", "The Role of Strict Anaerobes in the Digestion of Organic Material", and "The Microbial Ecology of the Activated Studge Process". Physical and hydrological considerations with dispersion of effluents are examined in "Disposal by Dilution" and the special problem of nitrogen and phosphorors compounds in water are examined in "Microbial Aspects of the Pollution of Fresh Water with Inorganic Nutrients". Additional papers focus on factors effecting algal blooms, biological nitrification and denitrification, the degradation of herbicides by soil micro-organisms, the microbial breakdown of pesticides, biodeterioration and biodegradation of synthetic polymers, and the special problems associated with the disposal of infective laboratory materials.

3. TRANSMISSION OF VIRUSES BY THE WATER ROUTE

Author: Edited by Gerald Berg, Robert A. Taft, Sanitary Engineering Center, Federal Water Pollution Control Administration, Department of the Interior.

Publisher: Interscience Publishers, a division of John Wiley & Sons, New York (484 PP; $15.00) 1966.

Point of View: "This volume is based on a symposium held December 6-8, 1965, in Cincinnati, Ohio. Each of the five parts of this volume, corresponding to the sessions of the symposium, was designed to bring together current knowledge and thinking in important areas bearing on the problem of virus transmission by water."

Level: Technical; numerous graphs and tables; some illustrations.

Summary: Published in 1966, this remains a standard reference in the literature on health effects of polluted waters. Papers are collected here under five main headings: Epidemiology, Quantatative Recovery of Viruses from Dilute Suspensions, The Minimal Infective Dose, The Viruses in Water, and Survival of Viruses in Waste and Waste Water. The questions addressed range from those concerned with the significance of viruses in water and the relationship among viral diseases, water supplies and water pollution, to those directed to the setting of research priorities and the determination of policy decisions and funding levels. For the most part, these are technical articles which assume some familiarity with the topics under discussion.

The two papers contributed to the first section, Epidemiology, address the transmission of viral diseases by drinking water (James Mosley) and the transmission of viral infections by recreational water. A variety of measurement and analysis techniques are described in the eight papers that comprise section two, "Quantatative Recovery of Viruses from Dilute Suspensions". These include hydro-extraction and two-phase separation, electrophoresis, passive hemagglutination, and the use of various chemicals and membrane chromatography. The third section, "The Minimal Infective Dose," includes six papers which cover a range of evidence for a variety of view points, all of them carefully documented with data from the research literature.

The two remaining sections, "The Viruses in Water" and "Survival of Viruses in Waste and Waste Water", are the most broad based and contain between them fifteen papers, most of them addressed to fairly narrowly defined research topics. In short, this is a very specialized volume

and while it retains an important and authoratative position in the literature, it is not one that is likely to appeal widely to readers other than those who are themselves familiar with research in this area.

4. PROCEEDINGS OF THE CONFERENCE ON PHYSIOLOGICAL ASPECTS OF WATER QUALITY

Author: Edited by Harry A. Faber and Lena J. Bryson.

Publisher: Research and Training Grants Branch, Division of Water Supply and Pollution Control, U. S. Public Health Service, Washington, D. C. (244 PP; $4.50) 1960.

Point of View: "This Conference on Physiological Aspects of Water Quality was organized to stimulate research interest in the physiological aspects of certain chemical constituents of water. The program was planned to focus attention on questions of what is known and what should be learned about the effects of minerals, trace elements, insecticides, and organic substances in potable water."

Level: Technical, Numerous diagrams, illustrations, tables and graphs.

Summary: Although now somewhat dated, these Proceedings report what has become a landmark conference in the history of water quality research. While it is difficult to believe that only a decade ago there was need to stimulate interest in what has now become an extremely active and productive field, that indeed was the intent of this Conference and many of the papers here report the very beginnings of research efforts in some areas.

There are twenty papers in all, plus several introductory statements and a conference evaluation contributed by Abel Wolman.

The first three papers address water quality problems: "The Need for Water Quality Criteria" (J. E. McKee); "Detection and Analysis of Chemicals in Water - Inorganic Constituents" (M. G. Mellon); and "Detection and Analysis of Chemicals in Water - Organic Constituents" (F. M. Middleton).

Two introductory papers, "Occurrence of Trace Elements in Water" (W. H. Durum) and "Quantitative Mineral Requirements" (D. M. Hegsted) precede the four rather narrowly defined research papers which comprise the section on "Minerals and Trace Elements". These examine separately the effects of four pollutants: Molybdenum, Selenium, Vanadium and Zinc. The two remaining sections provide three papers each on various aspects of insecticides (including an examination of phosphates and the effects of insecticides on aquatic life) and Organics (including a paper by W. C. Hueper on "Cancer Hazards from Natural and Artificial Water Pollutants").

Several summary papers conclude the volume, one of which is especially interesting historically: "National and International Standards of Water Analysis" by F. W. Gilcreas.

5. MICROBIOLOGICAL CONTROL AND OTHER SAFETY ASPECTS OF POTABLE WATERS

Authors: H. W. Wolf, Director, Dallas Water Reclaration Research Center, and A. R. Mixson, J., City of Dallas Water Reclaration Research Center.

Publisher: CRC Critical Reviews in Environmental Control 2(4): 557-567, January, 1972.

Point of View: "The Safety of our drinking water is a matter of concern to all people. Do our present supplies adequately meet established standards, and what is the prognosis for future supplies?"

Level: Semi-Technical.

Summary: This is essentially an exploration of and commentary on the criteria which must be met to ensure "safe" drinking water. The historical development of water quality criteria is traced and particular attention is paid to the concern for viral and heavy metal contents and organic chemical pollutants.

Beginning in 1850 with the epidemiological study of cholera and the Broad Street pump, the authors briefly trace the major advances that have marked the understanding of the role of water in public health. The potential for revising wastewater as drinking water is briefly examined in light of the findings of the 1969 Public Health Service National Community Water Supply Study. The major findings of that study are noted in a series of tables and accompanying text. Some general problem with existing Drinking Water Standards are noted and the authors conclude:

> ".... it is quite clear that our society is not paying adequate attention to the needs of its public water supply systems... the large municipal supplies do the better job of providing adequate quantities and qualities of drinking water... the lack of knowledge concerning viruses and the many chemicals is appalling in this day and age ... and, lastly, ... we are luckier than we are smart. There exists no great danger to anyone, but a great deal of comfort might be derived from more knowledge."

Useful primarily as a "State-of-the-Art" summary, this review provides excellent references to the lite ature and a good, general overview of a topic that is receiving increasing attention.

6. "DRINKING WATER"

Author: Janice Crossland and Virginia Brodine

Publisher: Environment 15 (3): 11-25, April 1973.

Point of View: "Forty one percent of U.S. drinking water supplies do not meet Public Health Service standards; contaminants include fecal bacteria, arsenic, cadmium, and hundreds of unmonitored chemicals."

Level: Non-technical; illustrated; numerous references cited.

Summary: Crossland and Brodine provide here an excellent summary of the current concern over the quality of our drinking water. Citing the findings of the 1969 Public Health Service National Community Water Supply Study as evidence of serious deficiencies in meeting minimum drinking water standards, the author's provide a careful review of the major contaminants and the potential hazards associated with each. Specific sections are directed to examination of toxic metals, organic chemicals, nitrates, deicing salt, chlorinated hydrocarbons, oil and chlorine. Some general remarks are included on biological hazards from impure waters and on the evidence for the resistance of various water borne diseases to current treatment and monitoring methods. A number of problems associated with existing standards for drinking water are briefly examined and the authors conclude:

> "Current standards and treatment processes are not adequate to provide water pure enough for drinking and swimming as long as the source of community water supplies and the sites of recreational water receive

Health Effects (cont'd.)

domestic waste, agricultural, and conservation site runoff and construction site runoff and industrial effluent. Reevaluation of present laws and institutions dealing with water is necessary for the protection of human health."

This is a particularly useful review of drinking water issues for non-specialists and provides excellent documentation for the reader interested in a more thorough understanding of the problems involved.

## III. FEDERAL POLICY AND LEGISLATION

### 1. WATER POLICIES FOR THE FUTURE

Author: Final Report to the President and to the Congress of the United States by the National Water Commission.

Publisher: US GPO, Washington, D. C. (579 pp.; Stock #5248-00006; $8.75) June 1973.

Point of View: "This report contains the Commission's conclusions and recommendations on the policies which it believes the Nation should adopt at this point in its history for the efficient, equitable and environmentally responsible management of its water resources."

Level: Non-technical; illustrated; numerous tables.

Summary: Prior to 1968, various Committees in Congress and agencies within the federal government were forced to deal in a fairly piecemeal fashion with matters of water policy. With the debate over the development of the Colorado River Basin, however, the Bureau of the Budget stepped in and recommended the establishment of a national water commission which would be charged with the review of water resource development on a national scale. The National Water Commission Act, passed in 1968, established that Commission under the following charter:

> The Commission shall (1) review present and anticipated national water resource problems, making such projections of water requirements as may be necessary and identifying alternative ways of meeting these requirements - giving consideration, among other things, to conservation and

Federal Policy and Legislation (cont'd.)

> more efficient use of existing supplies, increased usability by reduction of pollution, innovations to encourage the highest economic use of water, interbasin transfers, and technological advances... (2) consider economic and social consequences of water resource development ... and (3) advise on such specific water resource matters as may be referred to it by the President and the Water Resources Council.

Issued in 1973, this final report of that Commission is a massive document which deals in a fairly descriptive, non-technical way with a host of water issues and their policy implications. It is an excellent starting point for the study of water policy and includes some useful data on various aspects of water supply, use, and conservation.

Chapter 1, "Forecasting Future Demands for Water", provides a summary of water resources and the demands which will be put upon them in the years ahead. The last section in this chapter, "Alternative Futures", provides an interesting discussion of the variables which effect demand calculations and looks into a variety of possible forecasts.

Three chapters directed to fairly general background information follow: Water and the Natural Environment, Water and the Economy, and Water Pollution Control. This latter is by far the most detailed of

these chapters and explores some of the most basic issues: What is Happening to Water Quality? When is Water Polluted? Who Should Pay? and Who Should Regulate?

Chapter 5, "Improved Water-Related Programs" looks at a broad array of water programs, ranging from control of the Inland Waterway to monitoring of the waste heat problem in power production. All in all, about ten such programs are discussed and specific Commission conclusions and recommendations are included for each.

The problems of balancing developmental and environmental needs are briefly explored in Chapter 6, "Procedures for Resolving Differences Over Environmental and Developmental Values." Nuclear plant siting is given special attention, but the whole mix of impact statements, licensing procedures, legislative action, and agency review comes under the Commission's scrutiny.

Conservation potential is explored in Chapter 7, "Making Better Use of Existing Supplies", and particular attention is focused on improving ground water management, pricing as a means of motivating better use, transfer of water rights under the appropriation doctrine, and the reuse of municipal and industrial wastewater. The first recommendation here is one that is increasingly being implemented: "The potential for reuse of wastewater should occupy a prominent spot in future planning for overall water resources utilization."

Special issues related to "Interbasin Transfers" are explored in Chapter 8 in terms of the legal, social and economic considerations involved. This is followed by a fascinating chapter on the "Means of Increasing Water Supply", which includes discussion of desalting, precipitation augmentation, land management initiatives, and the

Federal Policy and Legislation (cont'd.)

potential for improving current water management technology.

Against this background, the report then moves to consider implementation of organizational arrangements, the problems of water management at the municipal level, the interface of federal and state jurisdiction in water law, Indian water rights, and the complex questions of who pays the costs of water development projects and how, specifically, water programs should be financed. These seven chapters comprise almost a third of the entire report and are clearly the area of major emphasis in terms of Commission initiatives and recommendations. The final chapter "Basic Data and Research for Future Progress", provides an excellent single-source reference on the dimensions of the water quality program and suggests the directions in which future research should and probably will be channeled. A series of four appendices is included, one of which contains the text of the National Water Commission Act. In short, this is an essential document in the literature of water policy and covers, in some detail, all of the major issues involved in the management of national water quality. (A separate volume, New Directions in U. S. Water Policy, which provides a summary of this material along with conclusions and recommendations set forth in this Final Report, is available from the GPO for $2.50).

2. CONSERVATION IN THE UNITED STATES: AIR AND WATER POLLUTION

Author: Leonard B. Dworsky

Publisher: Chelsea House Publishers, in association with Van Nostrand Reinhold, Co., New York (911 pp.; $30.00) 1971.

Point of View: "This compilation is designed to present at least some of the essential documents in the development of United States conservation policy. An attempt has been made to give adequate historical treatment and thus provide a broad background for the conservation issues likely to dominate political action in this field during the coming years."

Level: Non-technical.

Summary: The evolution of a national water policy has been a long and painstaking process and the record of that effort appears here and there in Congressional reports, agency documents, and in policy statements from this or that government official. What the Dworskys (Mrs. Dworsky is "an unsigned co-author") have done here, is to make a thorough search of the water and air pollution policy literature, and then turn the story of its evolution into a fascinating narrative. The "water story", which runs to a little over five hundred pages, is presented in the first half of this two-part summation and provides a uniquely thorough and entertaining history of the water conservation years.

The "Historical Prologue" which introduces the water pollution section begins with a brief discussion of the definition of water pollution and the sources of polluting substances. The American experience with water and its health implications is briefly traced from the experiences of the Colonial period to the evolution of new water technologies in the early 1900s. Beginning in about 1919, the emphasis is focused on efforts to assure potable drinking water and Congress in those years reviewed an impressive array of bills designed to provide the nation with clean water. It was not until 1948, however, with the passage of the Water Pollution Control Act, that a serious

national water pollution control program got underway. A brief review of that legislation is provided here, along with details of the several Amendments which were made to it in 1956, 1961, 1965, and 1966. The remainder of this introductory chapter examines the various attempts to design multipurpose water resources development and the evolution of interstate compacts and international agreements.

In the next section, "Water Pollution Problems and Developments Unitl 1948", the Dworskys look in more detail at early laws and conditions, science and water supply, epidemic disease, and the initial investigations into the pollution of interstate waters. Some of the major water-associated health epidemics are recounted, along with the sad beginnings of the pollution of the Great Lakes. This increasing awareness of the impact of water pollution led to greater interest at various levels of government and among diverse professional organizations, a development traced in "A Broadening Base of Concern" in which various public health and state government efforts are reviewed. This section concludes with a close examination of the initiatives begun in the Roosevelt administration and some interesting position papers and memoranda from FDR's administration are included.

The final section, "Developing a National Water Pollution Control Program: 1948-1968", provides an excellent summary of the legislation and policy decisions which underlie much of our current federal water policy. Of particular interest is the story of the evolution of the Interstate Agencies and a concluding case study examination which details the water pollution programs and policies for the state of Pennsylvania.

In short, this is a reference which should be essential reading for a variety of audiences: historians, legislators, conservationists,

planning officials, and general readers seeking a firm grounding in the evolution of our national water policy. It is an impressive volume, both in size and scope, and contains the kind of careful documentation indicative of thorough scholarship. It's one shortcoming, and this is one which will hopefully be corrected in the near future, is that it covers only through 1968 and there is, therefore, nothing here on the 1972 Amendments which are now defining much of our water policy initiatives. Even allowing for that slight reservation, however, there is nothing in the literature comparable to this volume and it should prove to be an extremely valuable basic reference for scholars and students alike.

### 3. LAWS OF THE UNITED STATES RELATING TO WATER POLLUTION CONTROL AND ENVIRONMENTAL QUALITY

Author: Compiled by the Committee on Public Works, U. S. House of Representatives.

Publishers: Printed for use of the Committee on Public Works, U. S. House of Representatives (Document #93-1) March, 1973 (522 pp; $3.10; GPO Order No. 5270-01765).

Level: Text of legislation.

Summary: This is an excellent companion volume to the National Water Commission's Summary Digest of the Federal Water Laws and Programs (Ref. II-4) and provides much of the specific detail that is missing in that compilation. This is of more limited scope, however, and deals only with water pollution control legislation passed by Congress from the River and Harbor Act of 1899 to the Federal Water Pollution Control Act Amendments of 1972. The texts of various Executive Orders and international agreements are included here,

along with a reprinting of the provisions of two important "Reorganization Plans", one of which, in 1970, established the Environmental Protection Agency. Unlike the Water Commission report, however, there is no editorial commentary in this volume and the various documents are simply reprinted in a loose, reverse-chronological order, beginning with the 1972 Amendments. Nevertheless, this is an invaluable policy reference and contains in one volume an inclusive and up-to-date record of Federal water pollution control legislation.

4. A SUMMARY DIGEST OF THE FEDERAL WATER LAWS AND PROGRAMS

Author: Edited by John L. DeWeerdt and Philip M. Glick, members of the National Water Commission legal staff.

Publisher: USGPO, Washington, D. C. (205 pp.; $1.75) 1973.

Level: Non-technical

Summary: As implied by the title, this is simply a compilation of brief descriptions of Federal water laws and programs. It is one in a series of some sixty reports which were prepared by the Commission staff as background to their major document, Water Policies for the Future (Ref. III-1). Included here, along with the information on the various laws and programs, is a very useful detailing of the statutory responsibilities of the nine cabinet departments and the more than forty federal agencies which are concerned with water-related activities. All of this is presented in a very concise, straight-forward manner and, while this is certainly no substitute for the primary legal documents, it is an excellent, time saving resource for anyone engaged in legal or policy research. It is

especially helpful for the non-professional who would otherwise be faced with a grueling and no doubt bewildering literature search. While there is not much detail here, one can at least identify the various laws, discover quickly what it is they cover, and find reference to their original text; that alone makes this an essential reference.

5. A LEGISLATIVE HISTORY OF THE WATER POLLUTION CONTROL ACT AMENDMENTS OF 1972

Author: Prepared by the Environmental Policy Division of the Congressional Research Service, U. S. Library of Congress.

Publisher: Printed for the Use of the Committee on Public Works, U. S. House of Representatives (Serial 93-1) January 1973. Available in two volumes from the USGPO: Volume 1 (1110 pp.; Stock #5270-01759; $.55) and Volume 2 (766 pp.; Stock #5270-01767; $3.70).

Point of View: "In order to preserve the context in which the Act was developed and to aid interpretation of provisions finally adopted, this detailed legislative history has been prepared."

Level: Non-technical.

Summary: This is a unique document in the literature of environmental legislation and it is one that should be of extreme interest to lawyers, scholars, environmentalists, and to those who must administer the requirements of the 1972 Water Pollution Control Act Amendments. Prior to the publication of these two volumes, the documentary history of this important piece of legislation was scattered through a variety of government documents, many of which had gone out of print or were available only to a specified audience. By compiling all of that information here, the Public Works Committee has made it possible to quickly and accurately trace the evolution of this Act and to search the original documents for the kind of explanatory materials that are, as a rule, known only to a select audience of legislators and staff

who worked on the drafting of the legislation. In short, everything of major importance that was was ever brought to bear on consideration of the provisions in the 1972 Act has been reprinted here and what emerges is both an informative and interpretative history of a specific piece of legislation along with a kind of case study of how an idea becomes law under our system of government.

Volume 1 opens with the text of the original legislation and then moves directly to the President's veto message and the debate which followed in both the House and Senate. The resulting "Report of the Conference Committee" follows, providing specific response to the objections contained in the President's veto message. There is some extremely interesting data mixed in here, both in the Report itself and in the debate which issued from it. The joint or compromise bill which resulted from all this is reprinted, accompanied by an impressive collection of amendments which were considered and, for the most part, rejected. While some of this manuevering is tedious and repetitious, it does capture and convey the kinds of conflict of interest considerations which were stimulated by debate on this bill and some of the correspondence and insertion into the record of journal and newspaper articles is actually quite informative. Finally, after almost 900 pages of debate and concession, the new bill emerges and is printed, along with the usual collection of objections and qualifying statements.

Volume 2 picks up with the Hearings on the new bill (H.R. 11896) and includes some very impressive testimony offered on behalf of the Administration by Russell Train, then of the Council on Environmental Quality, Paul McCracken, then Chairman of the Council of Economic Advisers, and William D. Ruckelshaus, then Administrator of the EPA. The main concern

here is with the magnitude and speed of the clean-up proposed in this particular legislation, and it is clear that the Administration objections fall into the category of "too much too fast."

Debate then moves to the Senate where the Public Works Committee, under the Chairmanship of Senator Muskie, began in November 1971 debate on a companion bill, S. 2770. A rather lengthy introduction to the legislative history of the bill is provided in Muskie's opening statement and this is followed by extended Senate debate on the bill. It is a remarkably complex bill, running to some 200 pages, and at times it is quite frustrating to try to follow the debate closely. Some of the confusion is cleared up in the Committee report reprinted at the conclusion of the debate testimony, "Federal Water Pollution Control Act Amendments of 1971", which provides a discussion of the intent of the legislation along with a section-by-section analysis of the provisions included under the various titles. Of particular interest is a brief summary of the costs involved and a record of the changes made in the bill as it progressed through debate. Finally, the text of the Senate bill as amended and eventually passed into law is provided, along with a very helpful and informative index which enables comparison of the provisions of this legislation to those already existing in the law.

Again, this is a reference document and not something likely to be read in its entirety by anyone other than scholars of Congressional history. It is, however, an excellent source of information on the intent and projected scope of the various pieces of Federal legislation. Some very useful economic data is mixed into the various debates here, but it is difficult to filter out in a first reading. In short, as is often the case with Hearings documents, there is a vast amount of useful information here,

but it is a frustrating and time-consuming task to get at it. What is readily accessible here, however, are reprints of several Congressional reports which provide summaries of the major questions under consideration and a comparative index which enables rather efficient review of the provisions of the outstanding pieces of water quality control legislation.

6. STRATEGIES OF AMERICAN WATER MANAGEMENT

Author: Gilbert F. White, Professor of Geography, University of Chicago.

Publisher: University of Michigan Press, Ann Arbor Paperbacks (155 pp.; $2.45) 1971.

Point of View: "The theme of this volume is that by examining how people make their choices in managing water from place to place and time to time we can deepen our understanding of the process of water management, and thereby aid in finding more suitable ends and means of manipulating the natural water system."

Summary: Among Gilbert White's many professional credits is his distinguished record of appointments to national resources planning commissions. Out of that experience has come this book, a careful, scholarly summation which promises to become a standard in the literature of resources management. Essentially, it is an analysis of the decision strategems which have determined our national water management policies. As such, it offers both a critical review of our past mistakes and a cautionary glimpse of what could be our future.

White begins his analysis by isolating for examination six types of strategies which have dominated the purposes, means and management of our

national water policy: (1) Single-purpose construction by private managers; (2) Single-purpose construction by public managers; (3) Multiple-purpose construction by public managers; (4) Single-purpose action by public agencies using multiple means; (5) Enlargement of these means to include research as a conscious management tool; and (6) A merging of multiple purposes and multiple means, including research. Each of these is described and exampled, with particular attention to three parameters: Who makes what choice? What is the effect upon the public welfare?; and, What is the effect upon the natural environment?

What emerges is a fascinating overview of the impact our decisions to date have had on the quality and quantity of our nation's water supply. An example of the irony of some of our more ambitious projects is provided in an early chapter:

> With the completion of the Glen Canyon Dam, the storage capacity on the main stem of the Colorado and its lower tributaries outside of the controversial Grand Canyon reach will have been fully appropriated. Indeed, there is reason to think that the storage surfaces provided with the completion of additional dams will generate a total amount of evaporation in a year exceeding the incremental gain in storage resulting from recent construction.

There are other disturbing observations here, but they are not the primary focus. They are symptons only, and White is careful

to treat them as such. This is no simple cataloging of past mistakes. It is, in fact, an optimistic book; it offers both an analysis of the character of our past decisions and a carefully reasoned strategem for improving on them in the future. What White sees as central to a better future is our ability to deal with this basic dilemma:

> The course of events of water management... indicates that the most important single factor clouding the horizon is the broadening gap between the level of scientific and technological knowledge and its sensitive application in daily practice. Irrigators fail to use watersaving devices, industrial managers ignore improved means of water processing. If the gap is to be narrowed, there will need to be a deeper appreciation of those conditions of decision which now impede the adoption of new practices.

To get from here to there, of course, we must show some common understanding as to our water needs and water quality goals. The ambiguities which enter into that aspect of the decision are substantial and White looks critically at several of them in Chapter IV, "What the Public Wants in Water Quality": Why Manage Water; What is Clean Water?; Types of Water Quality Standards, etc. He concludes with a call for closer collaboration between the natural scientists and engineers and their colleagues, the social scientists. Several specific areas for research

and collaboration are explored in Chapter V , "Research as a Tool: Confirmation and the Long Leap". Finally, in Chapter VI, White examines "regional integration", the direction in which water management strategies seem to be coalescing:

> ...the traditional analysis of regional opportunities in terms of linear projections of demand leading to long-range plans of public agencies to regulate a finite water supply is moving toward apprasial of a wider range of alternatives, including scientific research, and that the outcome is not a single 50 or 100 year plan but a set of guidelines within which projects by both public and private agencies may be undertaken.

White details the implications of this energy policy strategy in terms of its operational consequences and the kinds of organizational and administrative changes it will demand. Finally, he concludes by noting briefly the shift in man's attitude toward nature that is reflected in this policy transformation: "The emphasis shifts from construction to scientific probing, and from long-term commitment to short-term flexibility." It is a crucial shift, and it is clearly one in which White senses some promise for a more reasonable future. It is just this mix of critical analysis and optimism which makes this book so valuable and stimulating. It is surely one of the most thought-provoking commentaries on resource management to be published in this decade.

7. FEDERAL WATER POLLUTION CONTROL STATUTES IN THEORY AND PRACTICE

Author: Lettie McSpadden Wenner, Assistant Professor of Political Science, University of Illinois, Chicago Circle.

Publisher: Environmental Law 4 (2): 251-293, Winter 1974.

Point of View: "The answers that are given to the highly volatile political questions raised by pollution control must depend largely on the demands and stresses that are put into the political system by representatives of all parties to the controversy. It seems likely that such factors will continue to be more important in determining the quality of water in the United States in the future than any wording of laws or administrative structures developed to enforce them."

Level: Non-technical.

Summary: Environmental Law is a relatively new journal, published by the Northwestern School of Law, Lewis and Clark College. It is an excellent source of legislative histories and critiques in various environmental areas, as exampled by this essay on the federal role in water pollution control. On one level, this is an exploration of two questions: "What exactly is the state of our present water pollution control laws and the enforcement effort being made to implement them?"; and, "What, if any trend, can be ascertained from recent court decisions rendered under these laws?" Ultimately, of course, this is a commentary on the political process, on the kinds of non-legislative considerations which govern the actions of public officials. On both levels, it is a penetrating and revealing analysis.

Wenner begins by examining the law which is referred to alternately as the Refuse Act or the Rivers and Harbors Act of 1899. Originally

Federal Policy and Legislation (cont'd.)

intended as a means of keeping things like cow carcasses from interfering with the flow of water commerce, the Act was picked up by environmentalists in 1970 and received extensive media coverage due to several successful suits brought under its provisions. Wenner points out, however, that there are serious problems with attempting to control water pollution by this Act, and the implications of two important decision, Kalur v. Resor in particular, are noted. Wenner concludes:

> At the moment at least it appears that any government enforcement of the 1899 law has been suspended awaiting legislative amendments, higher court reinterpretation (both cases have been appealed), or change of polciy by administrators of the law.

The question remains, why have so many people involved with water pollution control turned to this vaguely worded law? The answer emerges from Wenner's review of federal legislation and administrative authority as it has evolved since 1899. Particular attention is paid to the 1948 Federal Water Pollution Control Act, to Reorganization Plan 2, which moved the function of water quality control out of HEW and into the Department of the Interior, and to Nixon's decision in 1970 to create a new agency, the EPA. Wenner notes that both the 1948 Act and the series of Amendments which have been made to it, were essentially concerned with providing funds for research and technical assistance, two functions of federal intervention which are not only tolerated but usually welcomed by otherwise reluctant local and state governments. The level of funding is briefly described and the results of the various programs are evaluated in terms of the 1969 General Accounting Office report ("Examination of the Effectiveness of the

Construction Grant Program for Abating, Controlling and Preventing Water Pollution"), which found that "many waste treatment facilities that had been constructed in the 1960's have had little or no effect on water quality". Wenner examines several reasons for that failure before turning to the even more frustrating problem area, federal enforcement. Although Wenner begins by noting that, "It is in this area that the most substantial changes have been and may yet be made", that optimism soon comes up hard against the reality of the state and federal perception of their respective roles:

> The attitude of federal officials traditionally has been that states retain primary responsibility for enforcing anti-pollution laws, and that the federal role is an assisting one. Polluters are well aware of these facts. A second traditional attitude of both federal and state officials has been that if "dilution" is no longer the "solution to pollution", neither is coercion.

Despite these limitations, Wenner foresees some hope in evolving Federal legislation and points in particular to the environmental impact statement provisions of the 1970 National Environmental Policy Act and to the increasing responsibility put on the EPA and other Federal agencies under the provisions of the 1972 Federal Water Pollution Control Amendments, which include authorization for "citizen action suits". Wenner concludes on a cautionary note:

As is the case with most new legislation, while some old problems have been resolved, more new questions have been introduced. Certainly the interest taken in this policy by both sides to the controversy has helped to clarify the policy direction that the Congress would like to see taken. Large questions remain, however, concerning the attitudes of the administrators of the law, and it would seem that arguments over the appropriate role that the federal government should play in water pollution are far from over. While it is entirely possible that the 1970's will continue to see Congressional activity in this field, even more important for the ultimate impact on our environment will be the attitudes assumed by both administrators and judges in their decisions to implement and interpret the various options now available under the legal framework.

## IV. BIOLOGY AND CHEMISTRY OF POLLUTED WATER

### 1. WATER POLLUTION MICROBIOLOGY

Author: Ralph Mitchell, Gordon McKay Professor of Applied Biology, Harvard University.

Publisher: Wiley Interscience, A Division of John Wiley & Sons, New York (416 pp.; $19.50) 1972.

Point of View: " The objective of this book is to provide a text for advanced courses in which modern microbiological concepts are applied to the solution of problems in water pollution control."

Level: Advanced Level textbook, numerous graphs, tables, diagrams, etc.

Summary: Designed to provide the student with help in obtaining "clear understanding of the fundamental nature of aquatic ecosystem and the effect of perturbations on them," this text provides a collection of analytical articles by the leading microbiologists in the seventeen areas chosen for discussion. These are grouped under six major headings: Microbial Charges Induced by Inorganic Pollutants; Intestinal Pathogens as Pollutants; Pollution and Community Ecology; Microbial Parameters of Pollution; and Microbiological Approaches to Pollution Control. All of this is introduced in an essay by Mitchell, "Sources of Water Pollution", which provides a brief overview of current research findings.

Eutrophication is examined in two of the three essays in Part I. "The Role of Phosphorus in Eutrophication" and "The Role of Nitrogen in Eutrophic Processes." Both of these provide excellent state-of-the-art summaries, along with extensive documentation. The final article in this section, "The Microbiology of Mine Drainage Pollution" provides

discussion of mine drainage classes, the microbiology of drainage water, Iron oxidation, and the growth of various ferrooxidans.

The four articles in Part II are focused on "Energetics of Organic Matter Degradation", "Stream Purification," "Biodegradation of Hydrocarbons in the Sea", and "Approach to the synthesis of Soft Pesticides".

Part III, "Intestinal Pathogens as Pollutants", contains an extremely useful, detailed and fully documented paper, "Water Borne Pathogens" (contributed by E. E. Geldreich of the Environmental Protection Agency) in which the author examines the public health significance of warm-blooded animal pollution and the transport of pathogenic microorganisms to the stream.

Two papers, one by Cairns and Lanza, "Pollution Controlled Change in Algae and Protozoan Communities" and the other by Mitchell, "Ecological Control of Microbial Imbalances" provide a useful introduction to the methodology of the analysis of polluted waters and the complex interrelationships of the bacteria, yeasts, fungi, alagae and viruses that comprise the aquatic ecosystem.

The most detailed discussion of water analysis and instrumentation is included in the four essays of Part V: "New Approaches to Assessment of Microbial Activity in Polluted Waters," "Biochemical Oxygen Demand," "The Coliform Count as a Measure of Water Quality", and "The Detection of Enteric Viruses in the Water Environment."

Finally, the two essays in Part VI, "A Critical View of Waste Treatment" and "New Approaches to Water Quality Control in Impoundments", provide summaries of two crucial topics. Both provide well-documented critiques complete with useful data. (For each of the papers in this volume, Mitchell has attempted "to provide the reader with both the information available ...and a critical assessment of that information by the persons most competent in the field").

Biology and Chemistry and Polluted Waters (cont'd.)

2. THE BIOLOGY OF POLLUTED WATERS

Author: H. B. Hynes, Zoologist, University of Liverpool.

Publisher: Liverpool University Press, 123 Grove Street, Liverpool 7, England (202 pp; $4.50) 1960.

Point of View: Straightforward descriptions of the chemical and biological components of water pollution and of the biological effects of pollutants.

Level: "It is not intended to be in any sense a text book, its aim being merely to explain in fairly simple terms the extent of our present knowledge ...". Writen for "managers and scientists, sewage works managers, civil engineers and fishermen ...".

Summary: This book is brief, old (published in 1960), and written by an Englishman; it would therefore appear to hold little interest for the present day American reader. In fact, however, it is a mirror classic which should still be the starting point of water pollution studies. It's continued usefulness stems from the basic goals of the author. He has provided, in multiple language and often with engineering illustrations, the background scientific information from which more elaborate and up-to-date studies can be built.

Of particular worth are the first four chapters, "The History of Water Pollution", "Natural Waters and Natural Qualities", "Ecological Factors and River Floras", and "River Fauna". The first of these describes not only examples of ancient pollution but of natural pollution. The second chapter goes on to describe the life cycles of rivers and lakes and the conditions against which pollution damage must be measured. The third and fourth chapters describe (and provide drawings

of in many cases) the flora and flauna of stream life.

The next seven chapters describe the major categories of water pollutants and their effects. Although there are two chapters on physical and chemical effects the emphasis is on biological effects, in particular on the biological effects of organic matter.

Chapter 12 describes "Other Human Influences on Natural Waters" - deforestation, daming, channeling and canal building, for instance. The last two chapters present the author's view on the need for more complete assessment of biological effects and on "Prospects for the Future". In this last chapter he makes a strong plea for recycling the nutrient ingredients of sewage and the heat that is wasted in cooling water.

This book has the expected weakness of its 1960 publication; it lacks much in the way of modern research reports, newer problems and newer solutions to problems. It was not intended, however, to emphasize either specific problems or solutions. Supplemented by more modern works, it retains its usefulness and would be an important primer in any beginning water pollution course. It is, in addition, written in such a charming and personal style that it deserves being recommended reading for that alone. It deserves the "classic" designation.

## 3. THE BIOLOGICAL ASPECTS OF WATER POLLUTION

Author: Charles G. Wilber, Chairman and Professor, Dept. of Zoology, Colorado State University, Fort Collins, Colorado.

Publisher: Charles C. Thomas, Springfield, Illinois (296 pp; $23.75) 1969.

Point of View: "In the present volume, there is no intent to present an exhaustive review of the literature. Rather, the author has selected references which to his mind seem most useful to illustrate pressing problems in the biological aspects of water pollution".

Level: "Hopefully this book will be useful to biologists, engineers, teachers, administrators, and others involved in water pollution problems. Although the volume was not designed as a textbook, it could be used in advanced courses for biologists and engineers who are being trained in water pollution control problems".

Summary: The sixteen papers which comprise this book provide an extremely useful summary of the research literature on a variety of water pollution topics. While some topics, such as the problems of the biological treatment of waste materials, are not treated here at all, there is excellent coverage of a wide range of important topics, including general toxicological considerations, ecological considerations, metals, oil pollution, pesticides, pulp mill pollution, sanitary sewage, industrial pollution, radionuclides, indicator problems, and siltation. For each of these topics, a thoroughly referenced chapter is provided which includes a review of the appropriate research literature, numerous tables, charts and graphs displaying relevant data, and an extensive set of references which comprise a useful listing of further reading for the interested student. A chapter on "Unique Problems" (Chapter 13) provides a very interesting and informative discussion of pollution by drought, the relation of air and water pollution, urban runoff, organic problems of the great lakes, acoustic pollution, marine waste disposal and its control, and ground water contamination. While the individual discussions are necessarily short, together they compromise a useful overview of the complexities of the water pollution problem. A similar function is served by Chapter 16, "Some Unsolved

Problems", which briefly reviews the status of current knowledge about biological productivity, fish kill studies, histopathology of pollution injury, stress, endocrine physiology, and shellfish contamination. Several tables of data (1964) on "Toxicities of Various Pesticides to Aquatic Animals" are included in an Appendix.

4. BIOCHEMICAL ECOLOGY OF WATER POLLUTION

Author: Patrick R. Dugan, microbiologist, Ohio State University.

Publisher: Plenum Press, New York (159 pp.) 1972.

Point of View: Straightforward description of the biochemistry of water pollution.

Level: Intended as an interdisciplinary summary for "chemists, ecologists, economists, engineers, lawyers, limnologists, managers, microbiologists, and politicians". Fairly technical chemical descriptions abound.

Summary: This is a brief and useful book which emphasizes the biochemistry of water pollution with relatively less said about specific causes or cures. It is divided into three parts: Part 1: The Water Pollution Problem (33 pp.): Part 2: Biochemical Considerations, (90 pp.), and Part 3: Major Ecological Problems (26 pp.).

In Part 1, the various pollutants are briefly described, including acid mine drainage, mercury pollution and the "recalcitrant molecules" such as DDT. Also included are a useful description of water and its properties, projections of supply and demand, and several valuable tables of data on regional supply and demand and specific water use, including cooling.

Part 2 is the most technical section. It begins with basic descriptions of ecological concepts and a further and useful description of "Water, Its Properties, Biochemistry, and Biological Implications." This chapter has interest beyond that of water pollution per se. The other chapters in Part 2 deal with the specific reactions which occur with the various pollutants; the last chapter briefly describes the cycling of nutrients.

Part 3 is divided between two topics, "Biochemistry of Acid Mine Drainage" and "Pollution And Accelerated Eutrophication of Lakes," and is therefore an excellent source of material on these two topics which are not as often treated in general water pollution discussions.

The book includes an extensive but now somewhat dated bibliography. It will be most useful as a reference document or advanced text rather than a reader, as its level is probably too technical for most students.

5. CHEMISTRY OF WATER SUPPLY, TREATMENT AND DISTRIBUTION

Author: Alan J. Rubin (editor), Associate Prof. of Civil Engineering, Water Resources Center, The Ohio State University.

Publishers: Ann Arbor Science Publishers, Inc. (446 pp.) 1974.

Level: Technical

Point of View: Scientific presentation of research result.

Summary: This book is an outgrowth of the Symposium on the Chemistry of Water Supply, Treatment and Distrubition held by the Environmental Chemistry Division of the American Chemical Society on April, 1973. It is composed of a collection of papers from that Symposium and suffers, therefore, from the variability of level and lack of continuity of such collections. There are, however, several papers of sufficient generality to make it

worthy of inclusion.

Chapter 1, by Gordon Robeck of the Water Supply Research Laboratory, NERC, Cincinatti, provides a useful summary, "Criteria Development for National Drinking Water Standards," which not only reviews the recent history of these standards as they apply to some of the newer pollutants, but presents and discusses the standards themselves.

The second chapter, "Nutrient Inputs to a Lake and Their Effects on Water Quality" by Aulenback and Clessier is also written at a level and on a subject which makes it helpful to a nonspecialist reader. It deals with nutrient inputs in a general way, with the role of lake sizes, shapes and watersheds and with the sources of nutrients including human activities. The general descriptions are supplemented by a case study of Lake George and by considerable data on that lake.

The two chapters are followed by 15 of a more narrowly technical nature. Subjects are, for instance, new methods of analysis - gas chromatography and the analysis of chlorine and other disinfectants - specialized chemical techniques for removing cadmium sulfur, and arsenic and the case of aluminum (III) Hydrolysis in alum coagulation. These three chapters are filteration techniques and problems with activated carbon, are on sand filters, and others dealing with chlorine and chlorination, and virial inactivation using bromine.

The 17th Chapter has some general interest as it reports on the effectiveness of the reverse ozination techniques in inaltioating viruses and bacteria. The last chapter "The Effect of Water Treatment and Distribution on Trace Element Concentrations" reviews some of the epidemiological evidence connecting trace element context of municipal water supplies and chronic disease and then describes the proper methods for assessing concentrations and the effects of treatment and distrubution on these concentrations.

**Biology and Chemistry of Polluted Waters** (cont'd.)

All in all this book will be of most interest to specialists but in a field dominated by the biologists it provides an overall view of the application of chemistry and is thus useful in obtaining a balanced view of the role of the various scientific disciplinies.

## V. MUNICIPAL WASTEWATER: COLLECTION AND TRANSPORTATION

### 1. DESIGN AND CONSTRUCTION OF SANITARY AND STORM SEWERS

Author: Prepared by a Joint Committee of the American Society of Civil Engineers and the Water Pollution Control Federation.

Publisher: American Society of Civil Engineers, 33 West 39th Street, New York, New York (283 pp.) 1960.

Point of View: "The manual should be considered as an aid to the practicing engineer as a check list of items to be considered in a sanitary sewage or storm drainage project, as represented by acceptable current procedure. It is not intended as a substitute for engineering experience and judgement, or as a treatise replacing standard texts and reference material."

Level: Technical; numerous illustrations and drawings, graphs and tables.

Summary: This is one in a series of ASCE manuals designed to provide an "orderly presentation of facts on a particular subject, supplemented by an analysis of the limitations and applications of these facts. It contains information useful to the average engineer in his everyday work, rather than findings that may be useful only occasionally or rarely. It is not in any sense a "standard", however, nor is it so elementary or so conclusive as to provide a "rule of thumb" for non-engineers." It is, however, an excellent state-of-the-art type study and has the advantage of having been assembled by joint effort of an ASCE committee and a broad range of reviewers and critics. This particular manual is full of references to additional sources under each of the chapter headings and is clearly meant as a distillation of a great number of technical reports and papers.

There are twelve chapters in all: Organization and Administration of Sewer Projects; Surveys and Investigations; Quantity of Sanitary Sewage, Quantity of Storm Water, Hydraulics of Sewers, Design of Sewer Systems, Appurtenances and Special Structures, Materials for Sewer Construction, Structural Requirements, Construction Plans and Specifications, Construction Methods, and Sewage and Storm-Water Pumping Stations. Each provides a carefully drawn summary of the state-of-the-art knowledge in each area, extensive supplementary data and, where necessary, appropriate engineering drawings and illustrations.

2. SEWERAGE

Author: Ronald E. Bartlett, British engineer and author.

Publisher: Elseiver Publishing Company, Ltd., New York (208 pp.) 1970.

Point of View: "This book draws on the author's experience of over twenty years with consulting engineers on schemes in the United Kingdom and overseas. It avoids detailed theoretical design and abtruse calculations as far as possible, and while it is intended mainly for engineers engaged on the design and construction of sewerage schemes, it is hoped that it will be equally useful to students."

Level: Semi-technical; numerous graphs, tables and diagrams; technical appendices.

Summary: Subtitled, "Public Health Engineering-Design in Metric," this is really a dual purpose book aimed at "combining an exhaustive summary of current thought and practice in the design of sewerage with an exercise in metrication." To that end, it is written entirely with the use of metric units and, while it takes some adjusting to at first, the current push

to "change to metric" may make these an increasingly valuable text in the U. S.

The fifteen chapters which comprise this discussion of sewerage run to about fifteen pages each and provide a fairly descriptive treatment of the major topics in the field of sewage collection and transport. These include site investigations, materials, contract and site organization, surface water sewerage, hydraulic design, structural design, manholes and other ancillary works, sewer construction, testing sewers, pumping stations, and rising mains. Directed to practicing engineers, the discussion at times has a kind of handbook or manual of practice tone, but for the most part the chapters are interesting and informative, providing concise explication with presentation of applicable formulae in metric units.

A series of six appendices provide additional technical material (weights of materials, miscellaneous formulae and tables, and conversion factors) along with two brief bibliographies and a series of definitions and abbreviations.

### 3. WATER POLLUTION ASPECTS OF URBAN RUNOFF

Author: U. S. Department of the Interior, Federal Water Pollution Control Administration, Water Pollution Control Research Series

Publisher: Final Report on the Causes and Remedies of Water Pollution from Surface Drainage of Urban Areas-Research (Project No. 120 of the Federal Water Pollution Control Administration, U. S. Dept. of the Interior,) STET American Public Works Association (Chicago: APWA) January 1969.

Municipal Wastewater (cont'd.)

Point of View: "... this project has had two values: It has provided procedures for measuring the water pollution potential of urban environmental wastes and evaluating their water resources effects in comparison with so-called "conventional" water pollution sources; and it has disclosed the relationship between better urban "housekeeping" practices and policies and the reduction of water pollution threats, thus adding another reason for community cleanliness and beauty."

Level: Semi-technical; numerous tables and graphs.

Summary: This is the most comprehensive treatment in print of a major wastewater transportation problem: urban runoff. It is the result of an elaborate investigation involving field studies, national surveys of municipal sanitation policies and practices, and studies of specific technical problems by staff and advisory personnel. As is noted in the introduction to the report:

> This study project has provided much needed data on the sources of these environmental wastes of urban areas, the nature and amounts of contaminants, and their potential pollutional effects resulting from the water-wastes interfacial contacts during precipitation and runoff incidents. It is true that some of the study data have been preliminary in nature; this does not detract from their validity. It is merely evidence that much of the work carried out under this project has been of an original nature and that such studies as these are intended to point out the need for further work in uncovering more facts and reaching additional findings and recommendations.

Municipal Wastewater (cont'd.)

The report itself is divided into ten sections: Findings and Recommendations; Objectives and Goals of the Study; Sources of Solids Causing Surface Pollution of a Unit Area in the City of Chicago; Sources and Amounts of Storm Water Runoff Pollution; Measures for Reducing the Pollution Potential of Urban Environmental Soiling; Cost of Prevention and Treatments; Responsibilities and Guidelines for the Elimination or Reduction of Pollution Potential of Urban Environment Wastes; and two concluding sections which provide acknowledgements and six appendices which provide descriptions and data on specific areas of investigation. Taken together they provide an excellent overview of the magnitude and character of this "secondary" source of urban water pollution. There are, in addition, references to numerous articles in the literature which treat various aspects of the problem and some very interesting data on the urban runoff problem.

4. COST TO THE CONSUMER FOR COLLECTION AND TREATMENT OF WASTEWATER

Authors: Robert Smith, Richard G. Eilers, Advanced Waste Treatment Research Laboratory, Cincinnati, Ohio.

Publisher: Project #17090, U. S. Environmental Protection Agency (Washington: USGPO) July 1970 (86 pp.; $1.00).

Level: Semi-technical, numerous tables & graphs.

Point of View: "This paper is intended to encourage and facilitate this educational process by attempting to assess in terms of dollars/capital/year the true cost of building and operating collection and treatment facilities for sewage and industrial wastewater."

Municipal Wasterwater (cont'd.)

Summary: Based on the 1968 Inventory of Municipal Waste Treatment Facilities in the United States, this analysis of the national average per capita cost for collection and treatment of municipal wastewater provides some interesting statistics on American sewerage. Data on the number of communities with various types of sewers and on the national breakdown of sewerage practice is provided in the introductory chapters. Brief discussions are provided of water contaminants, facilities required, and the status of collection and treatment in the United States.

By far the bulk of the report, however, is focused on the economics of American sewerage and sewage treatment practice: Cost Relationships, Cost of Municipal Collection and Treatment, Cost of Industrial Wastewater Treatment, Evaluation of the Treatment Backlog, Full Cost of Collection and Treatment, Governmental Expenditures for Grants-in-Aid, and Cost Comparison Between Collection and Treatment. The authors conclude:

> The cost of collection and treatment of municipal sewage does not represent a large fraction of personal consumption expenditures and the cost of public collection and treatment is significantly lower than the cost of individual disposal units such as septic tanks. From the cost estimates presented, it would appear that waste collection and treatment could be placed on a utility basis by increasing the sewerage charges now paid by a factor of about 2.5, provided the homeowner continues to pay for the house connections and municipal sewers as part of the price of the house or as a special assessment. If the entire cost of collection and treatment exclusive of the house connection is to be paid as a user charge, the amount

of the charge could exceed the present cost of water supply by about 40%.

5. OPTIMAL DESIGN OF URBAN WASTEWATER COLLECTION NETWORKS

Author: Jarvis S. Dajani, Robert S. Gemmell, and Edward K. Marlock

Publisher: Journal of the Sanitary Engineering Division of the American Society of Civil Engineers (SA 2) 98 : 853-867, December, 1972.

Point of View: "In a time of dramatically rising demands for public services, and of rapidly increasing costs of providing such services, there can be little question as to the need for developing improved design techniques, which would help the cause of efficient expenditures of public funds, in an area that has undergone very little change over the years."

Level: Technical; several tables; numerous equations.

Summary: Premised on the need for improved sewer design, this brief paper provides both a critique of current practice and a detailed analysis of the costs and engineering needs inherent in new strategies. The authors state their intent as follows:

> This paper presents an empirical analysis of the cost of constructing an isolated sewerline, identifies the outputs obtained from it, reviews developments in design methods, and presents an overall network optimization model which can be solved using commerically available computer soft-ware. It is believed that such a formulation will alleviate most of the present shortcomings of conventional design procedures ...

In "Live Haul Costs" a detailed analysis is provided of the capital cost of installing a wastwater collection system. A number of factors which determine these costs are isolated for analysis, with particular emphasis on the costs involved in the various physical components (pipelines, appurtanances, pumping stations, etc.) .. A brief discussion of ways to determine peak expected wastewater for a sewerline is provided in "Quantity of Flow", along with a detailed explanation of the mathematical model preferred by Babbit.

The remainder of the article is focused on "System Design" and specific discussion is provided of network layout and sink constraint. Essentially, this entire paper is designed to provide an empirical verification of a sewerline construction cost equation in the belief that such savings as adoption of this design might provide would represent potential improved efficiency in the expenditure of public funds.

# VI. MUNICIPAL WASTEWATER TREATMENT

## 1. MUNICIPAL SEWAGE TREATMENT: A COMPARISON OF ALTERNATIVES

Author: Prepared by Battelle Memorial Institute, Pacific Northwest Laboratories for the Council on Environmental Quality and the Environmental Protection Agency under Contract No. EQC 316.

Publisher: US GPO, Washington, D. C. Copies available from CEQ; EPA, and USG PO (385 pp.) February, 1974.

Point of View: "The purpose of this report is to provide a single document which can be utilized on a comparative basis, to develop preliminary selections of approrpiate wastewater treatment schemes for a municipality. The format of the text allows the reader to compare various treatment strategies on an energy, environmental, or economic basis and to develop cost figures which may better reflect a particular local situation."

Level: Semi-technical; numerous graphs and tables; bibliography.

Summary: Under the 1972 Amendments to the Federal Water Pollution Control Act, all municipalities must by 1972 provide secondary treatment of their wastewater. This report was prepared in an effort to facilitate decision making at the municipal level as to which wastewater treatment methodology would be most suitable to the needs of a particular community.

An introductory and summary section, written in a straightforward, non-technical style, provide a review of the treatment strategies and sludge handling options chosen for study within the text. Input-output patterns are described in terms of the impact of a wastewater treatment plant on three environments: air, land, and water. Detailed graphical summaries are provided to illustrate some of the comparisons which should be made in order to properly analyze and compare the wastewater treatment alternatives

available.

Two major sections follow: Liquid Treatment Strategies and Slude Disposal Options. Each provides a narrative description of several treatment options and their limitations: primary treatment with land disposal of effluent, waste stabilization lagoon, trickling filter, activated sludge, biological-chemical treatment, activated sludge-coagulation-filtration, tertiary treatment, physical-chemical treatment, and extended aeration, slude spreading, incineration, ocean disposal, sanitary land-fill and reclamation. A "Treatment and Disposal Process Profile" section follows, providing detailed data on the input-output characteristics of the systems studied.

Finally, in a series of appendices the authors review the specific theory behind the design of each treatment process and the specific assumptions utilized for each unit operation, process, or sludge handling option discussed in the study. Both the scope and detail of the coverage provided by this report is impressive. No other single document on municipal wastewater treatment in print provides the quantity of information here and few discussions of treatment strategy and methodology are as concisely or clearly written.

2. SEWAGE TREATMENT

Authors: R. L. Bolton and L. Klein

Publisher: Butterworth and Company, London, 2nd Ed. (256 pp.; $ 16.50) 1974.

Point of View: "A textbook like discussion of the "basic principles and trends" of sewage treatment.

Level: Semi-technical. "Those we had in mind when writing the book were foremen, working managers and young assistants on sewage works, public health inspectors and students of civil, municipal and sanitary engineering."

Summary: This is a comprehensive presentation of the basic principles and techniques of sewage treatment written by two British authors, one of whom is a manager of a treatment organization. This second edition is a revision and slight expansion on the first edition which was published in 1961. It is a fairly concise book of 256 pages. While it is semi-technical and emphasizes in particular the chemistry of sewage treatment it can be read profitably by any one with an understanding of the meaning of simple chemical terminology (oxidation and reduction for example).

The sequence of topics covered by the Chapters is quite traditional. The nature and chemical analysis of sewage is first, followed by descriptions of sewage systems, of preliminary and primary treatment and then the various topics concerned with secondary treatment: biological treatment, methods of improving final effluents, and sludge treatment and disposal.

There is a Chapter on effects of Trade Wastes (industrial wastes) and then four more specialized chapters on measurements and calculations and special purpose systems.

Sewage Treatment should serve the purpose described by the authors (see Level) but it will also prove useful to anyone whose interests in water pollution causes him to wonder exactly what takes place in a sewage plant. Its applicability for an American reader is broad inspite of the British origin. It uses metric and English units, the British Costs are usually converted to dollars and most of the examples are general enough to be common to both countries.

The usefulness of Sewage Treatment is extended by many tables of data, by a full list of conversion factors, and by "Suggestions for Further Reading." This latter, however, has only a few additions from the late Sixties, and most of the entries are now about 15 years old.

### 3. ADVANCED WASTEWATER TREATMENT

Authors: Russell L. Culp, general manager, South Tahoe Public Utility District, and Gordon L. Culp, manager, Water and Wastewater Management Section, Battelle - Northwest Research Institute.

Publisher: Van Nostrand Reinhold, "Environmental Engineering Series" (310 pp.; $14.50) 1971.

Point of View: "It is the purpose of this book to present the basic principles, enginering design information, and actual operating experiences related to treatment techniques which are relatively new to the wastewater treatment field..."

Level: Technical. "It is hoped that the resulting compilation will be of value to design engineers as well as to students and pollution control authorities."

Summary: This is, as the authors state in their preface, a technical book on advanced wastewater treatment. Its major readership will be engineers who must design wastewater treatment systems to produce essentially reusable water.

Chapter 1 is the least technical. It can serve as a brief summary of the need for advanced (beyond the secondary treatment now standard in most plants) treatment and privides also a helpful discussion of the various uses to which this treated water can be put and public attitudes toward reuse.

Municipal Wastewater Treatment (cont'd.)

The next nine chapters present, compare, and give practical design data on the various methods of final water treatment. There are chapters on coagulation and flocculation, sedimentation, ammonia removal, re-carbonation, and filtration. Activated carbon filters are given two separate chapters - one on reclamation techniques. There is a chapter dealing with the disposal of solids, the various sludges in particular, and a chapter on such newer treatment methods as ion exchange, chlorination and ozonation.

The last three chapters have training goals; they cover laboratory techniques, in particular the various control and monitoring tests, operator training and the design of a sytem to a specialized water quality.

The text is well supported with graphs, tables, half tones and drawings and each chapter has a list of references appended.

4. STATUS OF ADVANCED WASTE TREATMENT

Author: I. J. Kugelman, Research Sanitary Engineer, Advanced Waste Treatment Research Laboratory, EPA, NERC-Cincinnati, Ohio.

Publisher: Environmental Protection Agency, PB-213 819 (80 pp.; $6.00) May 1972.

Point of View: "... a general review of the advanced waste treatment program ... with special emphasis on those developments that are ready for full-scale engineering application."

Level: Technical.

5. WATER QUALITY IMPROVEMENT BY PHYSICAL AND CHEMICAL PROCESSES

Author: Earnest F. Gloyna and W. Wesley Eckenfelder, Jr., Center for Research in Water Resources, The University of Texas.

Publisher: University of Texas Press, Austin (448 pp.; $15.00) 1970.

Point of View: "... designed to focus attention on the latest developments in water quality improvement, particularly as directed to specific engineering applications."

Level: Technical, but can be read with profit by anyone with some knowledge of science.

Summary: This is the third volume of the six volume "Water Resources Symposium Series" which report the symposia conducted at the Center for Research in Water Resources of the University of Texas. The six volumes together constitute a valuable resource for the practicing engineer and the research worker, but are for the most part too technical to be included in this general bibliography. We have reviewed this volume, however, because it does include many articles of more general interest and because, while the discussions are often quite technical, they are not as deeply mathematical in presentation as are those in other volumes.

This volume is divided into four sections; section 1 deals with water quality criteria, section 2 with functional designs for removing solids, section 3 with designs for chemical treatment, and section 4 with sludge separations.

To the non-specialist section 1 may be the most useful. The first two chapters deal with water quality criteria and requirements in a general manner. The following chapters discuss the quality requirements

Municipal Wastewater Treatment (cont'd.)

Summary: While this review is intended for the wastewater treatment engineer and includes, where appropriate, chemical formula and technical vocabulary, it can be read with profit by anyone with some scientific training.

The article begins with a brief and mathematical summary of conventional primary and secondary treatment which is not only supported by illustration but also by tabular presentations of cost factors.

The body of the article deals, as advertized, with advanced treatments. These include three systems for removing small organic and collodial matter particles - microstrainers, deep bed filtration and chemical treatment. This is followed by descriptions of specialized techniques to handle the more difficult challenges now faced by treatment plant designers, phosphorus removal, nitrogen control, the removal of "refractory organics (those organics which resist removal by conventional means) and demineralization. Under each of these major topics the most recent developments are discussed; air stripping of ammonia, ion exchange, activated carbon aborption, ozonation and reverse osmosis are among those techniques described and compared.

The article is made even more useful by generous illustration, 23 figures and by 34 tables which provide comparative cost data and other data both from laboratory tests, pilot plants and full scale operation. A complete bibliography is included.

This paper is probably the best review of the advanced treatment process and in combination with "Municipal Sewage Treatment": "A Comparison of Alternatives" from the Brattelle Laboratories (reference 1, this section) would provide the necessary basic information on the entire sewage treatment process.

in a series of specific uses of water-fishiers, municipal reuse, recreation, agriculture and for cooling.

The second section, after two general chapters on U. S. and European practices, presents technical descriptions of the various solids removal techniques, filtration, microstraining, etc. The special needs of various industries are considered separately.

Section three deals specifically with chemical techniques and is the most technical of the four. Coagulation, phosphate precipitation, oxidation and reduction, ion exchange, active carbon absorption, reverse osmosis and other membrane techniques are described.

The fourth section deals exclusively with sludge separation and handling. The first chapger defines the important sludge characteristics and succeeding chapters treat thickening, filtration and conditioning, centrifugation, and disposal. The final two chapters treat the interlations of sludge separation and review European practices.

# VII. DISPOSAL AND UTILIZATION OF WASTEWATER TREATMENT SLUDGES

## 1. SLUDGE HANDLING AND ULTIMATE DISPOSAL

Author: James E. Smith, Jr., Research Sanitary Engineer, Water Quality Office, U. S. EPA.

Publisher: U. S. Environmental Protection Agency PB Z13-754 (17 pp.; $6.00) March 1971.

Point of View: "The purpose of this presentation is to discuss some alternative methods for the stabilization, dewatering, and ultimate disposal of sludges".

Level: Semi-technical.

Summary: This presentation is intended for engineers with some familarity with the overall waste treatment process. It is, however, a survey and does not enter into any of the topics in great depth. As a result it is readable by a non-specialist with a reasonable understanding of chemical and biological processes.

The presentation covers five major topics: (1) Sludge quantities and Characteristics in which the amounts of sludge produced by the different treatment processes is given along with data on the moisture control; (2) Stabilization Techniques, the several means of oxidizing the biological materials in order to prevent further degradation and the resulting noxious gases, etc.; (3) Techniques for Conditioning Sludge Prior to Dewatering; (4) Dewatering Processes (these are necessary for many forms of disposal since sludge is 90-99 percent water); (5) Ultimate Disposal, which includes land spreading and incineration.

The article contains a minimum of basic quantitative information in three tables which give data on amounts of sludge, the water content of

sludge produced by different treatment methods, and the cost of typical sludge handling processes. Despite the limited quantitative information here, this is a readable overview paper which should provide a useful introduction to this topic for readers with some scientific and/or engineering background.

2. SLUDGE RECYCLING: THE MOST REASONABLE CHOICE

Author: T. D. Hinesly, Soil Ecologist, University of Illinois.

Publisher: Water Spectrum 5 (1): 1-8, June, 1973.

Point of View: "Sludge, once stabilized, is too valuable a resource to dump into oceans, or burn or to permanently lagoon."

Level: Semi-technical. Assumes some familarity with sewage treatment techniques but is easily understood by a reader with a knowledge of simple biology and chemistry.

Summary: The author describes the pressures (increasing labor and land costs, increasing concern over water quality in rivers and ocean coastal areas) which will cause us to turn away from conventional sludge disposal systems.

He provides a brief description of the steps in sewage treatment that lead to the production of sludge and estimates the cost of sludge incineration, including the cost of providing air pollution controls for incinerators.

The body of the article is a description of the various techniques in use for land disposal of sludge. These include production and of sludge fertilizers, spray or furrow irrigation and such specialized techniques as the freezing and distribution of frozen sludge that is used in Canada. The preliminary results of the Chicago experiment with the transport of liquid sludge to downstate strip mined land are reported and used to

provide cost estimates.

The problems of erosion and of heavy metal buildup are discussed and recommendations for procedures to solve these problems are suggested. The advantage from an energy point of view recycling the nitrogen and phosphorous as fertilizers instead is argued.

The author's conclusion is as follows:

> "The average metropolitan sanitary district adapting sludge recycling to lands requiring extensive reshaping won't necessarily cut its monetary cost for treatment, but will provide environmental relief for the district - and improve productiveness on agricultural hinterlands receiving the sludge. And the deferred payment inherent in rebuilding nearby food producing soils will eventually provide a substantial return on this kind of waste treatment compared with current waste treatment programs.

3. AGRICULTURAL BENEFITS AND ENVIRONMENTAL CHANGES RESULTING FROM THE USE OF DIGESTED SEWAGE SLUDGE ON FIELD CROPS

Author: Report (SW-30d) prepared by T. D. Hinesly, O. C. Braids, and J. E. Molina, University of Illinois, under solid waste demonstration grant G06-EC-00080, to the Metropolitan Sanitary District of Greater Chicago.

Publisher: U. S. EPA, PB213-537/5 (62 pp.; 65¢) 1971. Single copies available from: Solid Waste Management Publication Distribution, Office of Solid Waste Management Program, U. S. EPA, 5555 Ridge Avenue, Cincinatti, Ohio 45213.

**Disposal and Utilization of Wastewater Treatment Sludges (cont'd.)**

Point of View: "In April 1974 the Federal solid waste management program together with the Metropolitan Sanitary District of Greater Chicago initiated a project to demonstrate the possible agricultural benefits and environmental changes that would result from applying digested sewage sludge to field crops. In addition, criteria are to be developed that can be used in selecting sites for this method of sludge disposal. This publication reports on the progress made after three year's work on this project."

Level: Technical.

Summary: Although the authors caution from the outset that this paper reports on only one year's collection of data, there is a great deal of useful information here on the feasibility of disposing digested sludge onto agricultural lands. In particular, the lysimeter facility at the University of Illinois is uniquely suited to test factors relevant to the bacteriological and chemical contamination of water and soils. Specific attention is directed in this report to the Properties of Liquid Digested Sludge with Respect to Land Disposal (Chemistry of Liquid Digested Sludge, Seed Germination in Liquid Digested Sludge , Volatilization of Ammonia from Liquid Digested Sludge, Effect of Digested Sludge on the Soil Atmosphere, Nitrification and Denitrification, and Digested Sludge Dewatering on Soils), Greenhouse Studies (on nutrient uptake and growth of corn on sludge treated plots), South Farm Lysimeter Research (fields, plant chemistry, soils and leachates), Instrumented Plots at the Northeast Agronomy Research Center (describing the facility supplemented field-plot studies) and Hogienic aspects of Liquid Digested Sludge Disposal on Cropped Land (fecal coli farms). The report concludes that:

1. "... the sludge fecal coliform population decreases following application to the soil or upon aging after removal from the digester. Lagooning of digested sludge prior to application would serve the purpose of reducing the fecal coliform population.
2. Nitrogen contained in digestive sludge is the most immediate limiting factor to rate of application ... . In the interest of higher loading rates, reduction of the nitrogen content of sludge could be desirable.
3. Heavy metals are an ubiquitous constituent of digested sludge and they occur normally in the solid phase.
4. Digested sludge has been shown to be an effective source of nitrogen, phosphorous, and micronutrients. Crop response to the water content has also been observed.
5. Sludge residue decreases the bulk density of the soil.
6. The rate of infiltration of digested sludge is low regardless of soil type.
7. Seed germination is inhibited by fresh digested sludge. ... properly digested sludge will produce no offensive odors after application to soil.

A brief bibliography is appended.

### 4. THE REUSE OF SEWAGE SLUDGE

Author: Robert B. Dean, Chief, Ultimate Disposal Research Program, Advanced Waste Treatment Research Laboratory, Federal Water Quality Administration, Cincinnati, Ohio.

Publisher: American Association for the Advancement of Science, "Symposium on Reducing the Environmental Impact of Population Growth", Dec. 26, 1970.

Disposal and Utilization of Wastewater Treatment Sludges (cont'd.)

Point of View: "Using sludge for fertilizer is analogous to using milk for bathing - it may be effective but it does not fully utilize the values in the fluid."

Level: Semi-technical. The reader needs some knowledge of the basic biological and chemical processes used in sewage treatment.

Summary: This article begins with a brief survey of the sewage treatment process which leads to sludge and then discusses the various methods of disposal. The advantages of land disposal are given major emphasis and a table comparing the costs of the various methods is provided. The author also examined some of the disadvantages of land disposal of sludge and prescribes several ways to avoid these.

The statement quoted in the point of view above leads into a discussion of more sophisticated means of utilizing sludge. This waste material contains proteins , carbohydrates, fats, and vitamins which are chemically similar to substances used in animal food: "Indeed they have the same origin and it would be difficult to distinguish between dried primary sludge and many animal feed supplements from their proximate chemical analyses." The author reports on some experiments on the utilization of the potential food value of sludge and on the generally favorable experiments with its use as a supplement in animal feed.

The conclusion is that pressure cooking of sludge with sulfur dioxide may allow a small profit to be associated with sludge disposal and at the same time help the protein shortage and lower the cost of meat products. As far as a human food source is concerned, the NASA experiment which he briefly reports are not encouraging. His conclusion is the following

> "Even though sludge bacteria cannot be used as a source of human food, their utilization as animal feed is an efficient form of sludge recycle and can help improve the world's supply of preferred proteins. No trace of the genetic source of the amino acids could survive ... The constituent amino acids will carry no more information about their origins than does a pile of reclaimed bricks from an urban renewal site."

5. LAND APPLICATION OF LIQUID MUNICIPAL WASTEWATER SLUDGES

Author: Robert J. Manson and Clifford A. Merritt.

Publisher: Water Pollution Control Federation Journal 47 (1): 20-30, January 1975.

Point of View: "The objective of this article is to emphasize that wastewater sludge should be treated as a natural resource, rather than as a problem-ridden product requiring disposal".

Level: Semi-technical; illustrated; several tables; bibliography.

Summary: Essentially, this is a report of a survey on sludge management practice in Northwestern, Ohio. A brief summary of the data collected on 75 treatment facilities is provided, followed by a description of some particularly successful examples of communities practicing land application of sludges.

In the body of the article the authors examine several criteria as to their importance in the design of land-application systems: Isolation (from residential areas), Slope, Soils, Application Rate, Ground Cover, Monitoring, Equipment, and provide something of a "manual of practice" on land application

techniques and contains some very useful information. The final section, "Conclusions", states the advantages of direct land application in succinct form:

1. Money invested in land is never lost.
2. The return on the sale of the sludge-fertilized crops helps pay for the entire operation.
3. It is a true disposal method as well as a method of resource recovery.
4. It is a simple and straightforward method in comparison with most methods presently in use.
5. Equipment and operating costs are low.
6. This method is highly flexible, both in application techniques and in the type of crops that may be grown.
7. It has little environmental impact.

An extensive bibliography, directing the reader to some thirty-six reports and papers, is appended.

## VIII. RECYCLING AND REUSE OF MUNICIPAL WASTEWATER

### L. WASTEWATER TREATMENT AND REUSE BY LAND APPLICATION - VOLUME I - SUMMARY

Author: Charles E. Pound and Ronald W. Crites (Metcalf & Eddy, Inc.).

Publisher: U. S. EPA Report 660/2-73-006a (80 pp.; $1.10; $1.10; USGPO) August 1973 (PB 225 940).

Point of View: "A nation wide study was conducted of the current knowledge and techniques of land application of municipal treatment plant effluents and industrial wastewaters. Selected sites were visited and extensive literature reviews were made."

Level: Technical.

Summary: Three categories of land application techniques are examined in this report: irrigation, overland flow, and infiltration - percolation. A description of each technique is provided and each is evaluated as to its effectiveness under conditions of current practice. The report's general conclusion states:

> There is a paucity of quantitative information in the literature on the removal efficiencies of soil systems with respect to wastewater constituents.

Irrigation is singled out as the most promising technique: "Irrigation is the most reliable land application approach evaluated on the basis of direct wastewater recycling, renovation, long term use, and minimization of adverse environmental effects. "Overland flow ("grass filtration") is given a good evaluation also, but the authors note that "systems have not been in operation long enough to determine long term effects or expectant period of use." While irrigation percolation has

has been shown to be effective in several ongoing systems, the author's conclude that as a technique it is "less reliable than irrigation from the standpoint of wastewater renovation and long term use."

Extensive data and descriptive information on the various techniques is provided throughout the report, along with a set of recommendations regarding the implementation of land application projects, development of standard practices and research needs. Included in the appendices are a useful list of sixty-four references, titles of additional Pound and Crites publications, a glossary of terms, abbreviations, and conversion factors and a series of tables giving the name, city and state of projects listed in the preparation of this report. In short, this is the most comprehensive evaluation of the various techniques for the treatment and reuse of wastewater by land application.

2. NEW DIRECTIONS FOR WASTEWATER COLLECTION AND DISPOSAL

Author: Daniel A. Okun, Professor of Environmental Engineering, University of North Carolina at Chapel Hill.

Publisher: Journal Water Pollution Control Federation 43(11): 2171-2180, November 1971.

Point of View: "Wastewater is a resource and, out of both necessity and economy, reuse must be planned."

Level: Non-technical.

Summary: Despite its title, this is more a discussion of wastewater reuse than wastewater collection and disposal. Okun begins by underlying the need for the regionalization of water supply systems with wastewater facilities into larger regional water resource management systems. Noting the arguments

against reusing wastewater for drinking water, Okun reviews the various alternative uses that recycled wastewater has been put to in several European countries and suggests that:

> ...wastewater may be used directly for purposes that do not require the high quality that is necessary when the water is to be used for drinking. Every urban center has within it and in its immediate environs many water needs that can be met with water of lesser quality, such as industrial use for process and cooling, irrigation, long-scale cleansing operations, such as for streets and automobiles, recreation, and the creation of aesthetically pleasing water bodies in recreational areas.

Okun notes that high-quality drinking waters are currently used to meet many of these purposes and points to cities like Los Angeles and Pomona where reclaimed wastewater is beginning to find a market among large users who previously bought the more expensive and unessentially high-quality potable water. An informative version of the development of reclaimed wastewater as a resource is then provided and Okun notes the most meaningful experiments to date. A discussion of the characterization of wastewater, chemical treatment, treatment in wastewater systems and pressure conditions provides a useful overview of current state-of-the-art technology. Okun concludes by noting the need for more and better trained manpower for wastewater treatment facilities.

3. RECYCLING TREATED MUNICIPAL WASTEWATER AND SLUDGE THROUGH FOREST AND CROPLAND

Author: Edited by William E. Sopper and Louis T. Kardos.

Publisher: The Pennsylvania State University Press, University Park and London (479 pp.; $16.50 ) 1973. Proceedings of a Symposium conducted by the College of Agriculture and the Institute for Research on Land and Water Resources, The Pennsylvania State University, in cooperation with the Pinchot Institute for Environmental Forestry Research, Forest Service U. S. Department of Agriculture, Office of Research and Monitoring, U. S. Environmental Protection Agency.

Level: Technical; numerous tables and graphs.

Point of View: "The specific purpose (of this symposium) was to review and discuss current knowledge related to the potential of using land areas for the disposal of wastewaters and to determine technological gaps and research needs."

Summary: This "state of the art" symposium on land disposal of municipal wastewater and sludge has quickly become a standard reference in the field of municipal wastewater recycling. These proceedings consist of thirty-two papers collected under ten topics: Treated Municipal Wastewater - What is It?; Fundamental Functions of the Soil and Its Associated Biosphere; Wastewater Quality Changes during Recycling; Soil Responses; Vegetation Responses; Other Ecosystem Responses; Systems Design, Operation and Economics; Examples of Operating and Proposed Systems; Present Status of Guidelines for Land Disposal of Wastewater, and a final section on Research Needs.

While the papers vary individually in the complexity of their treatment, there is a wealth of information here, much of it in a form suitable for non-professionals. There is some particularly useful and interesting information on the status of various federal and state level programs and some very straight-forward discussions of the economics involved in the various systems. In short, this is a concise, up to date, summation of the current state-of-the-art in a field which is attracting increased interest and funding. Some excellent data summations are provided and many of the papers provide very useful suggestions of further readings in the literature.

4. SEWAGE FARMING

Author: Jonathan Allen, graduate student, physics, Washington University, St. Louis, Missouri.

Publisher: Environment, 15 (3): 36-41, April 1973.

Point of View: "The author describes the advantages and discusses some of the problems of using municipal wastewater to irrigate farm land."

Level: Popular, although some technical topics are discussed.

Summary: Although successful and sophisticated "sewage farming" has been carried out for 100 years or so in many European communities, it is only recently been accepted in the U. S. as a reasonable alternative to conventional treatment. The author describes some of the foreign experiences, notably the farms serving Paris and Berlin which have been in existence since mid 19th Century, and the more recent farms in Israel. In addition, he reports on the results of the smaller scale experimentation at Penn State.

Advantages, disadvantages, and costs are briefly examined. The benefits include reduced water pollution, crop improvement, better utilization of source water, and reduction in demand for chemical fertilizers.

The most serious disadvantage is apparently the heavy metal accumulation caused by industrial pollution. This might require segregation of industrial sources for pre-treatment. It will also be necessary to control the rate of application in order to control saturation of the soil and the buildup of salts.

The presently scanty data on comparative costs is also discussed; most of these are from a recent (1972) Chicago study. Both capitol and operating costs are expected to be lower for the irrigation techniques than for the other two systems, advanced biological treatment and physical chemical treatment (which includes incineration). The comparison is even more favorable if environmental costs are assigned to the other system and farm output credited to irrigation.

This article serves as an adequate introduction to and a brief for sewage farming and provides a bibliography of more technical references. It could be used effectively, for instance, to stimulate student interest in the subject as part of a deeper student project.

5. WASTEWATER REUSE - A SUPPLEMENTAL SUPPLY

Author: John D. Parkhurst.

Publisher: Journal of the Sanitary Engineering Division ASCE (SA3) 96: 653-663, June 1970.

Point of View: "While only a portion of our wastewater is suitable for treatment and reuse, it should be considered in its proper role - as a supplemental supply."

Level: Semi-technical.

Summary: One option that is being explored in the debate over the potential of wastewater reuse is a "middle ground" solution that would use treated wastewater as a supplemental water supply. This paper reports on the potential of such a scheme for the Los Angeles area:

> "...each day, over 700,000,000 gal. of once-used wastewater of varying quality are still being discharged ofter treatment through the submarine outfalls operated by the City of Los Angeles and the sanitatation District of Los Angeles County into the Pacific Ocean. With present technology, a substantial portion of this wastewater could be safely and economically processed to produce a high quality water suitable for augmenting existing and future supplies. Some of this water is superior chemically to that imported from the Colorado River."

Parkhurst documents his contention with data comparing wastewater samples from the Whittier Narrows Water Reclaration Plant with untreated Colorado River Aqueduct Samples. Cost of the Whittier reclaration process are provided and a summary is given of the effect this water has had on the local ground water quality. Several of the more promising advances that have emerged from the R & D Program of the Sanitation Districts of Los Angeles County are noted including investigation into several treatment methodologies: carbon adsorption, reverse osmosis, ion exchange and electrodialysis. Some cost figures are provided for tertiary processes and a brief summary section re-emphasizes the potential of using treated wastewater as a supplemental water supply.

## IX. ECONOMIC ASPECTS OF WATER POLLUTION CONTROL

### 1. THE OUTLOOK FOR WATER: QUALITY, QUANTITY, AND NATIONAL GROWTH

Author: Nathaniel Wollman, Professor of Economics and Dean of the College of Arts and Sciences at the University of New Mexico; Gilbert W. Bonem, Chief of Research and Evaluation of the Model Cities Program in Albuquerque.

Publisher: Published for Resources for the Future (RFF) by the Johns Hopkins Press, Baltimore (352 pp.; $12.00) 1971.

Point of View: "Our study seeks to develop a systematic economic model that (1) recognizes the regional aspects of the water problem yet yields a national perspective; (2) permits aggregation of demand and supply into usefully parallel concepts; (3) takes into account the fugitive and probabilistic characteristics of supply as well as the interdependence between supply and demand; and (4) identifies important choices to be made and tensions to expect within and among water resource regions.

Level: Semi-technical; some background in statistics and economic analysis is assumed; numerous tables, graphs and equations.

Summary: Water, because of its unique and elusive characteristics, is one of the most difficult national resources to analyze in terms of future supplies and requirements. The problem is succinctly summarized in the foreword to this study:

> Because most common property resources are large natural systems with their own pulses and rhythms, we face supplies that are highly variable in time, both systematically and randomly. Water is heavy and must be used in large quantities, so that purposefully transporting it over long distances is usually foreclosed. Accordingly, dealing in national aggregates as the

other projection studies have done has very little meaning - intraregional and itterregional analyses must be performed.

In attempting to provide this analysis of water as a commodity property resource, Wollman and Bonem were operating in an area where new data had to be collected and new analytical tools had to be developed for its analysis. This report reveals something of the difficulties involved in the undertaking and provides in the process an excellent collection of water supply-demand data and the exposition of what is considered a unique and extremely valuable methodology for analyzing the national water resources problem and the choices which are available to us. A description of the methodology employed is provided in Part 1, "The Study in Brief", which explains the problem, the approach, the basic model and its variations, and also suggest the kinds of uses to which the study might be put. A brief summary of the study findings is provided, along with a statement of the authors conclusions and their implications for various policy issues and the setting of research priorities. This is all quite straight-forward and nontechnical, providing an excellent overview summation for the general reader.

The second part of the study is really addressed to the authors' colleagues in economics and related professions. A vast amount of data has been collected for this section and, while the explanatory material and mathematical equations may well be prohibitive to the non-specialist reader, the chapters here provide an excellent, single-source reference on water supply-demand data. The specific topics addressed in this section are: Population and Economic Activity Projections to the Year 2020; Coefficients of Water Use: Withdrawal Uses; Withdrawals and

Losses: All Uses; Water Quality; The "Supply" of Water and the Costs of Flow; The Basic Model: The Results; Short-Term Tertiary Treatment and Reduced Storage; and Variations in Selected Parameters. The authors are cautious in making any claims for the results of their study and point to the inherent uncertainities in many of the numbers generated. Some general conclusions are offered, however:

1. Rapid growth projections a half century into the future suggest that high quality water on a wide scale will be possible only if we find quite new technologies for using the resource.

2. Even in the nearer term, high growth combined with high water quality targets mean vastly expanded capital and operating costs for facilities - primarily waste treatment.

3. The Southwest will remain a hard-core area of quantitative water shortage with the upper Arkansas-White-Red and perhaps several other regions sharing its fate within fifty years, even with medium growth.

4. On a national scale, quality is a much more difficult and costly problem than quantity, and large-scale investment in water facilities will shift from its traditional homes in the irrigated West to the East.

The evolution of sound water management policies will depend on a thorough understanding of the vital issues addressed in this research. Wollman and

Bonem have provided with this report a stimulating basis for further advances in the art of projecting water supply and demand.

2. THE ECONOMICS OF CLEAN WATER - 1973

Author: U. S. Environmental Protection Agency Report transmitted by Russell E. Train to the U. S. Congress.

Publisher: U.S. GPO, Washington, D. C. (120 pp.; Report #EP 2.14:973, $ 2.50) December, 1973.

Point of View: "The scope of this report is broader than previous reports. For the first time, economic factors - essential to a broad assessment of control programs and policies - are examined. Particular attention is afforded those factors that may constrain implementation of control programs. Also examined for the first time are two major sources of nonpoint pollution - agricultural soil loss and nitrogen fertilizer."

Level: Non-technical; an annual report to Congress; numerous tables and graphs; bibliography.

Summary: This is the sixth in a series of annual reports on the economics of clean water and is the first submitted to Congress by the EPA under the provisions of the Federal Water Pollution Control Act. Unlike the previous reports, which tended to consider the costs of controlling pollution as sufficient information upon which to evaluate a national program, a concerted effort has been made in this document to take into account a broad range of variables: the nature of the water quality problem, the costs of controlling all significant sources of pollution, potential benefits, and economic and administrative factors that influence

implementation. Essentially, however, while all of these factors are addressed to some degree, this remains a rather tightly focused analysis, concerned primarily with the economic factors that will influence implementation of the 1972 Federal Water Pollution Control Act Amendments.

The report is presented under seven chapter headings. The first of these provides the usual summary of the study content and conclusions. In the second chapter, "Nature of Trends in Water Pollutants", the authors examine various pollutant-related phenomena and review the results of EPA's 1972 analysis of the water quality of the nation's 22 major rivers. A table of the survey results is provided, along with a detailed review of the findings for three of these rivers. Municipal costs are examined in Chapter 3, with special attention to the status of public sewerage and the implications of the 1973 National Needs Survey, which was conducted in accordance with the requirements of the 1972 Amendments. There is some interesting data here, particularly on construction costs of new public water treatment facilities.

By far the most detailed section of the report is Chapter 4, "Industrial Costs", which examines specific sources of pollutants and the capital costs involved in correcting for industrial waste discharges. The major focus in all of this is on the costs which industry will incur in meeting the 1977 effluent standards set by the 1972 Amendments. The opening sections here provide a broad analysis of those costs, excluding only those related to utility steam-electric generating plants. In the closing paragraphs of the chapter, the costs and impacts associated with these plants are discussed separately.

Nonpoint pollution is examined in Chapter 5 as to the nature of the problem, soil loss-export policy models, fertilizer limitation policy models, and the implications of these costs to the nation's farm programs. What results from this analysis is the conclusion that not all farm regions "possess the characteristics needed to have their incomes improved or maintained under conditions of prevailing farm programs or a free market situation". In other words, there is no fair way to uniformly, across all regions, offset government supply control programs with adoption of environmental measures.

A different perspective on all this is provided in Chapter 6, "Benefits from Water Quality Enhancement", and the authors consider such parameters as water quality as an input into production, water quality when consumed with another good, and water quality as a factor in human health. This is by far the most generalized discussion in the report and contains a fairly extensive bibliography of supplemental readings. Finally, the last chapter, "Constraints", provides a review of the Amendments in terms of their fiscal impact on local government, the economic impacts on directly discharging industries, the implications for the construction industry, and the related problems of supplying abatement equipment to meet the new effluent standards.

To some extent, this 1973 Report assumes that the 1972 Report will be used as a companion or supplementary volume. There is certainly a great deal more in the way of data and detailed analysis in the three volumes than comprise that earlier edition. Volume 1 (USGPO Stock #5501-0377; 157 pp.; $1.75) provides a general discussion of the magnitude of water pollution in 1971 along with a detailed discussion of trends in water use

and treatment and separate sections on the planned construction of municipal waste treatment facilities and the environmental and economic benefits and costs related to various water pollution abatement strategies. Volume II, "Data and Technical Appendices", (USGPO Stock #5501-0378; 696 pp.; $4.75) contains a brief, introductory section, followed by print-out of data under three headings: Basic Data and Results of Industrial Facilities Evaluation Model; Pollution Index-Federal Administrative Region Summary; and Survey of Planned Construction of Municipal Waste Treatment Facilities.

Finally, a brief summary volume (US GPO Stock Number 5501 - 0379; 33 pp.; $.55) provides an interesting and useful analysis of the purpose and scope of the whole report along with brief, analytical treatments of the following topics: Costs and Planned Investments (Industrial and Municipal); Trends (Ambient, Manufacturing, Construction Industry); Evaluation of Benefits and Costs; and a Summary of Methodologies and Models Used in Analysis.

3. WATER POLLUTION CONTROL BENEFITS AND COSTS

Author: Volume 1, Samuel G. Unger, M. Jarvin Emerson and David L. Jordening; Volume II, David L. Jordening and James K. Allwood, Economic Analysis Branch, Implementation Research Division, Washington, D. C.

Publisher: Prepared for the Office of Research and Monitoring, U. S. Environmental Protection Agency, Washington, D. C. (Volume 1) (198 pp.; $2.10) October 1973.

Economic Aspects of Water Pollution (cont'd.)

Point of View: "The state-of-art surveyed presented attempts to classify and assess benefit cost analyses applied to water resource management problems in light of relatively recent serious concerns involving environmental quality issues .... The principal objective of Volume II is to specify research needs and priorities involving water pollution control costs and benefits."

Level: Semi-technical; some background in economics is assumed; numerous tables and graphs.

Summary: This two-volume study is one in a series of reports issued by the EPA Office of Research and Monitoring as part of its "Socioeconomic Environmental Studies" program. It is directed to the description of research on the socioeconomic impact of water pollution control and contains both a state-of-the-art summary (Volume I) and a summary of research needs and priorities (Volume 2). It is difficult reading, directed to an audience with a fairly sophisticated economics background, but it contains the kind of data and explanatory material that should be of interest to every student of water pollution control problems.

Volume I, "State-of-Art Review: Water Pollution Control Benefits and Costs", contains a very useful summary of current knowledge concerning water pollution control costs and benefits, along with a general statement of their implications for planning and research. Traditional benefit cost analysis is extended into the area of pollution control and a conceptual basis for benefit cost analysis involving water quality management is suggested. The concept of social welfare function is explored as the most commonly accepted criterion for measuring environmental quality concerns. Problems of efficiency, equity, externalities, and social

discount rates are outlined and an assessment is provided of the adequacy of information in these areas. It is suggested that, with recent efforts to directly assess impacts of environmental quality management, "benefit cost analysis will effectively become a supplementary analysis of alternative sets of simulated general equilibrium types of economic solutions." The authors conclude that:

> The state-of-the-art in identifying and measuring benefits and costs from pollution control is in an embryonic state of development ... Only in the past few years has significant attention been directed to evaluating pollution control mechanisms in response to shifting public priorities in the direction of environmental quality.
>
> The conceptual and empirical base upon which benefit and cost analysis of environmental policies could build has been oriented primarily toward development objectives. The metrics of traditional benefit cost analysis include income, output and employment. But with regard to pollution, it was recognized that policies designed to increase economic activity generally resulted in an increase in pollution. The sources of pollution stem from various types of activity. Likewise the receptors of both pollution damage and benefits from pollution reduction may be considered to be similar activities. Consequently, traditional benefit cost analysis has been of limited value as a building block in evaluating policies designed to improve the environment.

Economic Aspects of Water Pollution (cont'd.)

In Volume II, "Research Needs and Priorities", a series of theoretical and methodological research needs are presented, taking into particular account the findings reported in Volume 1 as to the common property aspects of water pollution control and the complications inherent in the prevalence of externalities. An important distinction is made between the economic costs of pollution and the costs of pollution abatement. It is noted that the economic costs of pollution, such as damages, efficiency reductions, increased production expenses, etc., are a function of water quality, whereas pollution abatement costs are typically a function of the degree of pollution control. The authors suggest that, for comparable cost comparison, a transformation of pollution abatement costs in terms of water quality is desired and this transformation and the problems it presents are discussed in some detail. Finally, in a series of technical appendices, the following topics are treated: water pollution control cost and benefit estimates; water quality associated health impacts; specific pollutant sources, damages and potential treatment methods; and critical levels and damage thresholds for selected pollutants.

4. WATER AND RELATED LAND RESOURCES: ESTABLISHMENT OF PRINCIPLES AND STANDARDS FOR PLANNING

Author: United States Water Resources Council, Rogers C. B. Morton, Chairman. (The Council is an independent Executive agency of the U. S. Government).

Publisher: United States Water Resources Council, Suite 800, 2120 L Street, N.W., Washington, D. C. 20037. (Reprinted in: Federal Register 38 (174): 24778 (Part III) Monday, September 10, 1973).

Point of View: "These principals are established for planning the water and related land resources of the United States to achieve objectives, determined cooperatively, through the coordinated actions of the Federal state, and local governments ... Plans for the use of the Nation's water and land resources will be directed to improvement in the quality of life through contributions to the objectives of national economic development and environmental quality."

Level: Technical; a rather sophisticated background in economic theory is assumed.

Summary: Any attempt to set cost-benefit evaluations in regard to natural resources is bound to bring controversy, and this report is no exception. It is based on a rather extensive effort undertaken by the United States Water Resources Council pursuant to the Water Resources Planning Act (P.L. 89-90).

The preliminary recommendations of that study, published in 1971 (Federal Register 36, p. 24144) raised considerable criticism (see Science 181: 723-727, 24 August 1973) as to the quality of economic analysis which had gone into the report. This revised set of principles and standards attempts to correct for some of the problem but, as there has not yet appeared in the literature an independent evaluation of its success on that score, it is included in this bibliography with the recommendation that the reader familiarize himself with the earlier report and the response in the literature which it has generated.

Underlying the Council's recommendation here is the following assumption:

The overall purpose of water and land resource planning is to promote the quality of life, by reflecting society's preferences for attainment of the objectives defined below:

A. To enhance national economic development by increasing the value of the Nation's output of goods and services and improving economic efficiency.

B. To enhance the quality of the environment by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.

The ordering of priorities, with economic considerations taking precedence over those of environmental quality, has been a major source of contention between the Council and various environmental organizations and spokesmen. At any rate, it is the fundamental assumption taken here and it strongly affects the benefit-cost determinations which are delineated in the report. Whatever problems there may yet be with the report's analytical methodology, it is an important document in the literature as it represents one of the first attempts at the federal level to provide a comprehensive discussion of economic evaluation issues.

It is a complex report and, for the non-economist, it can often be quite baffling as there is very little in the way of explanation of the economic methods employed in arriving at the specific cost-benefit determinations. It would be an oversight, however, not to include this

document among the references reviewed here, and we do so with the recommendation that it is most suited for study by those with a fairly sophisticated background in economic theory.

5. WATER POLLUTION: ECONOMIC ASPECTS AND RESEARCH NEEDS

Author: Allen V. Kneese, Economist, Resources for the Future.

Publisher: Resources for the Future, Inc., 1775 Massachusetts Avenue, Washington, D.C. (107 pp.; $1.75) 1962.

Point ov View: "Public agencies and industry will probably spend tens of billions of dollars on new water pollution abatement facilities in the next few decades. Added billions will be spent for the operation of new and existing facilities. How can physical science research reduce the cost of achieving objectives? And how can social science research make sure that the right objectives are being efficiently pursued?"

Level: Semi-technical

Summary: Published in 1962, this survey of the technical and economic aspects of water pollution control has become a classic in the literature. It's author, Allen Kneese, continues to be a leading spokesman of resource management economics and the organization which sponsored the study, Resources for the Future, Inc. (RFF), continues to publish a broad range of excellent economic analyses (see Ref. II-1). Despite its early publication date, this is a valuable and insighted reference which continues to provide an excellent introduction to the problems, economic and technical, which effect water resource policy.

Part I, "An Economic Framework", provides an outline for the conceptual foundation of public policy, points to the problems inherent

in the economic analysis of water requirements, and defines the approach and assumptions of this particular survey:

> In this study waste disposal is viewed as an aspect of economic activity in an economy where the allocation of resources to alternative uses is accomplished primarily by market processes. The special circumstances surrounding waste disposal are recognized as grounds for public intervention and for the insertion of some politically determined values into the processes of public policy formation. The primary purpose is to conceptualize the pollution problem in a way that helps to identify types of physical, economic and social knowledge that are basic to intelligent policy in the pollution field.

The nature, effects, treatment, and alternatives to treatment of water pollution are presented in a brief but quite useful summary chapter which deals with major pollutants and their effects on receiving waters, effects of pollution on water uses, and the various treatment methods available. Kneese concludes this discussion by noting that technical considerations alone cannot determine policy and that values must be introduced into the decision-making process. He further notes that there are, in fact, grounds for considering values that arise from other than market-type valuations and it is to this aspects of the problem that he turns in the next chapter.

Economic Aspects of Water Pollution (cont'd.)

Chapter III, "Economic Efficiency, Social Policy, and the Pollution Problem", begins with a discussion of the "welfare maximizing" results of market processes. Kneese delineates, in broad terms, "the ways in which unregulated market results with respect to water pollution fail to coincide with the requirements of an ideally functioning market system." A hypothetical situation is described to illustrate some of the appropriate directions that federal policy might take in dealing with this problem and Kneese notes the implied political valuations in these policies and their functions in a competitive market system.

The general framework for approaching economic aspects of public pollution is outlined in Chapter IV, "Evaluation - Determination and Integration of Individual and Social Values - Focus of Public Policy". Kneese examines the social objective of waste water disposal policy, the role of public policy, and the implications or "non-market" social goals. The chapter concludes with the identification of four broad areas where research should be able to improve the planning process. Appended to this final chapter in Part I is a brief paper on "Benefit Cost Analysis and the "Constrained Cost Minimization" Framework". This concludes the discussion of the methodology for outlining a conceptual foundation for public policy and, in Part II, Kneese moves on to the discussion of "Research Needs".

The topics treated in this second part of the survey correspond to the four research areas identified in the last chapter of Part I. In Chapter V, Kneese looks in some detail at the computational and scientific problems involved in determining the effects of wastes on receiving water. Chapter VI is focused on "Deficiencies in Technical and Economic Knowledge", with particular attention directed to the issues of damages, treatment, and

abatement costs. In Chapter VII, Kneese evaluates the problems involved in devising procedures for approximating optimum systems. Several possible approaches are suggested and brief discussions are provided of the techniques of simulation and programming and the problems of timing and sequence. Finally, Chapter VIII provides a summary of Part I and a brief review of selected research needs. Kneese concludes:

> This study has shown that any effort to establish efficient water-supply and waste-disposal systems is bound to beset by a host of information deficiencies, which cut across the boundaries of a variety of traditional disciplines.

It is an observation which still holds true and it is interesting, having read this study which is now twelve years old, to look at the policy decisions of the last decade and compare them to the recommendations set forth in these chapters.

## 6. COSTS OF WATER POLLUTION CONTROL

Author: Proceedings of a national symposium on costs of water pollution control, sponsored by the Research Triangle Universities and the U. S. Environmental Protection Agency, edited by F. Eugene McJunkin.

Publisher: The proceedings may be ordered from: Water Resources Research Institute, 124 Riddick Building, North Carolina State University, Raleigh, North Carolina, 27607 (276 pp.; $8.00) July 1972.

Point of View: "Pollution abatement is generally recognized as a national goal of highest priority. Because of the costs involved, however, it is imperative that public policy be soundly conceived and economically and socially feasible. The makeup of incentive systems can markedly affect

costs and acceptance. Reasonable goals attained through economically efficient means hold great promise. Untenable goals through efficient means can bring both failure and disillusionment."

Level: Varies from non-technical policy papers to semi-technical economic analyses; numerous tables and graphs.

Summary: This symposium preceded by several months the passage of the 1972 Amendments to the 1965 Clean Water Act. The policy changes proposed in that legislation and, in particular the kinds of economic questions raised by the so-called "zero discharge" provision, serve as a focus for many of the papers delivered during the symposium. While cost estimates have gone up dramatically since the publication of these proceedings, they do provide an excellent introduction to some of the cost-effectiveness problems raised by our national water policies. Most of the papers are brief, well illustrated with graphs and tables, and quite suitable reading for a non-technical audience. This is particularly true of the three papers which make up the opening session: "Evolution of Public Attitudes and Actions on Water Pollution Control", "Two Trillion or Three: The Cost of Water Quality Goals", and "Economic Implications of Alternative National Policies for Water Pollution Control". This latter topic is picked up in a luncheon address following the opening session, in which a representative of the National Wildlife Federation rebuts some of the optimism put forward by the EPA as to what is really known about the nation's water resources and how they should be managed.

"Cost Effectiveness" is the title of the afternoon session and the five papers included here are again well documented and full of useful information on real and projected costs of meeting various water quality criteria. Some particularly interesting information is provided in the concluding paper,

Economic Aspects of Water Pollution (cont'd.)

"Economic Guidelines for Analysis of Joint Industrial-Municipal Collection and Treatment Systems".

A different perspective on water problems is provided in the Banquet address by William H. Matthews of MIT, who reports on water resource issues raised at the 1972 United Nations Conference on the Human Environment.

Of the three sessions which make up the second day's Proceedings, the first two, "Costs" and "Economic Insights" are especially appropriate to this packet. "Effective Pollution Control Investment", the paper which introduces the "Costs" section, looks at the ways in which the EPA is trying to "assure the effective investment of Federal funds for water pollution control facilities", mostly through careful monitoring of their construction grant program. The two papers which follow provide brief discussions of "The Present and Future Market for Pollution Control Equipment" and "Financing and Charges for Wastewater Systems." Broader policy issues are addressed in the "Economic Insights" session with paper on "Pollution Control Policy and the Efficient Allocation of Resources", "Economic Incentives in Water Pollution Control", and "Water and Wastewater Surcharges as Economic Incentives." Finally, the closing session, "Industrial Wastewaters", looks at the questions of pricing competition and the kinds of benefits which might accrue to industries which expend monies on pollution controls. Brief examinations are provided of two industries in particular, the chemical industry and the paper industry.

This, then, is a good, quick summary source on recent thinking, findings, and projections as to the costs of water pollution control. It is well suited to a non-technical audience and is a good source of data on the general economics of the problem of water pollution.

## X. EUTROPHICATION: A SPECIAL CASE

### EUTROPHICATION: CAUSES, CONSEQUENCES, CORRECTIVES

Author: Proceedings of the International Symposium on Eutrophication, University of Wisconsin, June 11-15, 1967.

Publisher: National Academy of Sciences, Washington, D. C. (661 pp.; $13.50) 1969.

Point of View: "Participants in the International Symposium on Eutrophicsation agreed that we need greater knowledge of the processes involved in eutrophication. Furthermore, we should study eutrophication on an ecosystem basis. The limits of the system cannot be drawn at the water's edge but must include the waters of lakes, their sediments, and their drainage basins. Such a multifacted approach will benefit from computer simulation models."

Level: Varies from paper to paper; for the most part, technical to semi-technical.

Summary: This is a classic reference on eutrophication, one which is referenced with regularity in the water pollution literature, and which contains some of the most authoriative papers by authors considered as having very best papers in print on the topic of nutrients in water. The proceedings provide a very broad, international perspective on the dimensions of the eutrophication problem and there is collected here a wealth of information which would otherwise be very difficult to assemble.

The thirty-four papers which comprise these proceedings are organized under six headings. The first of these, "Introduction, Summary and Recommendations", provides a very brief overview of the conference findings. There is a short discussion of what eutrophication is and how it comes about and then a paragraph or two on each of several recommendations put forward by the conference participants.

Eutrophication: A Special Case (cont'd.)

Section II, "Eutrophication, Past and Present", consists of one paper of the same title, delivered by G. E. Hutchinson of Yale University. It is an excellent statement of the evolution of the limnologists' understanding of eutrophication and provides a valuable introduction to the topic.

Some of the most interesting material here is gathered together in the third section, "Geographical Concepts of Eutrophication", and the papers here provide a most useful record, both of what is known worldwide about the problem of eutrophication and of how the problem manifests itself in the lakes of Central Europe, Asia, Northern Europe, Eastern Europe, and North America. As is the case throughout these proceedings, excellent documentation accompanies each paper and the interested reader will find reference to numerous articles and books which treat the various aspects of the study of eutrophication.

By far the most technical material in the Proceedings appears in Section IV, "Detection and Measurement of Eutrophication", where most of the papers address the various indices employed in monitoring water quality and the findings relative to the effect of eutrophication on fish, zooplankton, phytoplankton, and bacteria. In the section which follows, "Preventive and Corrective Measures", some of the engineering and management problems effecting eutrophication are discussed. Finally, in "Contributions to Science from the Study of Eutrophication", papers are provided on everything from algal nutrition and eutrophication induced physiological stresses to aspects of feeding in zooplankton and the effects of enrichment in mathematical models. In short, this is an excellent single-source reference on eutrophication and contains papers on a broad range of eutrophication-related topics, many of them contributed by the foremost experts on this problem in the world.

## 2. NUTRIENTS IN NATURAL WATERS

Author: Herbert E. Allen and James R. Kramer

Publisher: Wiley Intersciences, John Wiley & Sons, New York (457 pp.; $22.50) 1972.

Point of View: "The serious aquatic chemistry problems involve nutrient concentration in natural waters, methods to control these levels, and the effects of nutrient enrichment. As our rivers and lakes become utilized by larger numbers of persons... the problems mount. Adequate solution of our nutrient problems requires familiarity on the part of scientists, engineers and government officials... with all aspects of the chemistry, geochemistry, and biochemistry of nutrients as these fields relate to natural waters.... This book has been prepared to meet that need."

Level: Technical, numerous tables and graphs; extensive documentation.

Summary: All but one of the chapters here has been adapted from a symposium, "Nutrients in Natural Water," held at the 161st Meeting of the American Chemical Society in March, 1971. For the most part, they are quite technical and report on recent research into various aspects of the chemical problems associated with high nutrient concentrations in natural waters. Contributions here include experts in the chemical and biological sciences and in engineering, representing educational institutions, government, and industry.

There are fifteen papers in all, beginning with a basic, overview paper, "Nitrogen: Sources and Transformations in Natural Waters." A detailed examination of phosphorus in water, biomass and sediment is provided in the second paper and an extremely interesting analysis, "The

Carbon Cycle in Acquatic Ecosystens" is provided by the third paper. Three technical papers on analytical methods follow: "The Chemical Analysis of Nutrients"; "Bioassay Analysis of Nutrient Availability" and "Nutrient Submodels and Simulation Models of Photoplankton Production in the Sea." The next four papers focus on the nutrient problems of specific lakes, Lake Erie in particular: "Oxygen - Nutrient Relationships Within the Central Basin of Lake Erie"; "Changes in C, N, P and S in the Last 140 Years in Three Cases from Lakes Ontario, Erie, and Huron"; "Effects of Sediment Diagenesis and Regeneration of Phosphorus with Special Reference to Lake Erie and Ontario," and "A Chemical Model for Lake Michigan Pollution: Considerations on Atmospheric and Surface Water Trace Metal Inputs". Two very informatiove State-of-the art papers on "Wastewater Treatment by Physical-Chemical Processes" and "Nutrient Removal from Wastewater by Biological Treatment Methods" are included. Finally, the role of the federal government in controlling nutrients in natural waters is summarized and a brief review of the development of nutrient control policies in Canada is provided.

### 3. BIODEGRADABLE DETERGENTS AND WATER POLLUTION

Author: Theodore E. Brenner, Technical and Materials Division, The Soap and Detergent Association, New York.

Publisher: Pages 147-196 in Advances in Environmental Sciences, Vol. 1, James N. Pitts, Jr. and Robert L. Metcalf (New York: Wiley Interscience) 1969.

Point of View: "While no comprehensive analysis has been made of the very extensive data collected by the Federal Water Pollution Control Administration on MBAS Levels in rivers and streams throughout the country, a general review of this information indicates that levels have dropped.

Eutrophication: A Special Case (cont'd.)

When coupled with the fact that reported foam incidents in natural waters have decreased dramatically... this would indicate that MBAS levels have reached a point where they are no longer of practical concern to pollution abatement authorities."

Level: Semi-technical; several tables.

Summary: Essentially a state-of-the-art paper on the evolution of detergents as water pollutants, this discussion provides both a useful historical summary of research findings and a fairly thorough review of the chemical and biological processes involved in this particular pollution problem.

Brenner begins with an examination of detergents themselves - what they are chemically, how they work, and the reasons for their increasing popularity over the last twenty years. Particular attention is paid here to the role of surfactants, such as ABS. Noting the inadequacy of water treatment, a problem that accompanied the introduction of detergents, Brenner briefly reviews the changing character of water treatment processes and identifies the need for construction of secondary treatment systems. A brief review is then provided of early detergent foam incidents and of the findings produced by a series of investigations into the problem. With the isolation of ABS as the chief culprit, a search was begun for an ABS replacement and Brenner documents the kinds of formulation and the criteria that were applied to the research. Careful explication is provided here of the basic chemical formulae involved and to the characteristics of the ABS replacement, LAS. This leads naturally to a discussion of the mechanisms of biodegradation and the methodology of biodegradability testing. Field studies, both at sewage treatment plants and on individual household disposal units are reviewed in terms of their findings as to the effects of the introduction of LAS and, in "Post Conversion Experience", Brenner

Eutrophication: A Special Case (cont'd.)

notes that the switch seems to have been a successful one: "There is solid evidence that changes are occurring and that MBAS levels have dropped in rivers and streams." Brenner concludes with a few, brief comments about the parallel situation in some European countries and provides a listing of some seventy citations for those readers interested in a more detailed study of the detergent problem.

4. WATER POLLUTION - 1970

Author: Hearings before the Subcommittee on Air and Water Pollution of the Committee on Public Works, U. S. Senate, 91st Congress, Second Session, June 8, 1970.

Publisher: Printed by the U.S. GPO for the use of this Committee on Public Works (Part 4; 1610 pp.; $1.00) 1970 (44. p 96/10:W29/2/970/pt.4).

Point of View: Testimony at these public hearings on various aspects of water pollution was taken from representatives of industry and government, and from interested citizens.

Summary: As is often the case with government hearings, this brief volume provides both a good deal of useful information about the topic under discussion, eutrophication, and also a good "inside" view of the interaction between government, industry and the general citizenry.

Most of the testimony taken here is from representatives of the various detergent manufacturers, and each has come supplied with a set of research papers defending the much maligned phosphates in detergents, the ingredient which has been as playing a major role in eutrophication problems. There is some useful technical information here and a valuable insight is provided into the problems that have plagued both government and industry in dealing with the phosphate problem.

Arsenic is the focus of the early discussion and papers here, particularly in terms of the human health implication. The paper, "Arsenic in Detergents: Possible Danger and Pollution Hazard", provides a good summary of this phosphate-related problem.

The bulk of the remaining testimony and papers is provided by representatives from two companies: Monsanto Chemical Co. and the FMC Corporation. The FMC paper, "The Eutrophication Problem: A Review and Critical Analysis (The Non Role of Phosphates in Eutrophication)" provides an excellent statement of the detergent manufacturer's position. An interesting exchange of information by Senator Eagleton, and the remainder of the text is made up of reprinted articles. One, a New York Times article, "Warning: The Green Slime is Here", presents a good summary of the eutrophication process, what it is and how it comes about and what might be done to alleviate some of the problem. Several research papers from the U.S. and Canada are reprinted, and a final Swedish paper, "Enzyme Based Detergents" takes an interesting look at a possible alternative to the use of phosphates in detergents.

## 5. RELATION OF PHOSPHATES TO EUTROPHICATION

Author: Charles M. Weiss, Professor of Environmental Biology, University of North Carolina.

Publisher: American Water Works Association Journal 61 (8): 387-391, August 1969.

Point of View: "Not only is eutrophication hard to define, but the role of phosphorous as its chief causative factor also remains unclear. A number of recent experiments, however, do shed some light on both problems."

Eutrophication: A Special [illegible] (cont'd.)

Level: Semi-technical; several tables and diagrams; documented.

Summary: Good coverage of several topics is provided in this brief paper, beginning with an examination of several definitions of eutrophication and finally settling on "the process of enrichment with nutrients." The whole range of problems associated with phosphorous in water is reviewed and several useful references are cited in the introductory paragraph. A brief look at "Steady State Ecology" follows along with an examination of unbalanced aquatic ecology. A useful diagram of the phosphorous cycle in water accompanies the text. Weiss then turns to an examination of the total range of growth factors affecting algae growth and reports on the results of several laboratory experiments on macronutrient levels, nutrient input rates and nutrient relationship problems. Some very useful summary data is provided here, both in the text and in the several tables that accompany it. Weiss concludes with a set of observations on the complex nature of the role of phosphate in eutrophication and provides an excellent selection of pre-1969 papers which should be valuable to the reader interested in exploring this topic more fully.

6. PHOSPHATE REPLACEMENTS: PROBLEMS WITH THE WASHDAY MIRACLE"

Author: Allen L. Hammond

Publisher: Science 172: 361-363, 23 April 1971.

Point of View: "...the non-phosphate products available today are far from perfect; in addition to some possible detrimental environmental effects, there are unanswered questions about their safety and washing effectiveness."

Eutrophication: A Special Case (cont'd.)

Level: Non-technical

Summary: This is an excellent, brief non-technical summary of the complexities which characterize the problem of phosphate pollution from laundry detergents. The focus here is on three aspects: detergents in the ecosystem, options in detergent formulation, and social options.

A very readable and informative overview of the detergent problem is provided in the first section, outlining the scope and nature of the detergent problem and the many unknown characteristics of eutrophication that remain to be determined.

Attention is then shifted to consideration of alternatives to phosphates and a good summary of the problems with substitutes like NTA and the polyelectrolytes is provided. The possibility of developing surfactants that would work without a sequesting agent is briefly analyzed and some useful comments are provided as to the potential role of small manufacturing companies in changing the research picture. Finally, in "Social Options", Hammond examines the questions of the feasibility of developing treatment plants which would remove the phosphates. Kinds of trade-offs involved in phosphate replacement are voted and Hammond concludes by asking what may be the crucial question in all this debate: "...is whiter than white necessary, or will simply clean do?".

WATER POLLUTION

Part II, Industrial Wastewaters

## I. BASIC GENERAL REFERENCES

### 1. LIQUID WASTE OF INDUSTRY, THEORIES, PRACTICES & TREATMENT

Author: Nelson Leonard Nemerow, Professor of Civil Engineering, Syracuse University.

Publisher: Addison-Wesley Publishing Company, Reading, Massachusetts (584 pp; $22.95) 1971.

Point of View: "This book is intended to meet the needs of many people: the college professor who teaches environmental engineering, the consulting engineer who seeks a solution to his client's problem, the municipal engineer who must understand the waste problem well enough to explain it to city officials and point out remedies, the industrial plant engineer who wants to prevent his company from polluting the water that receives his plant's wastes, the Environmental Protection Agency technical personnel charged with administering the Water Quality Act of 1970, and engineers at state and regional levels who are faced with the immediate and readily visible problem of pollution abatement."

Level: Technical; really a graduate level text, complete with graphs, tables, and some fairly sophisticated mathematics; some illustrations; numerous references.

Summary: For a comprehensive treatment of the problems of industrial waste-waters, there is really nothing to compare with this text. It has some obvious shortcomings, in terms of general readability and the tendency to rely on somewhat dated references, but these are minor flaws in an otherwise excellent treatment of industrial wastes issues. While Nemorow writes in a very straightforward, presentation-of-information style, he has managed to incorporate an impressive amount of material here without overwhelming the reader.

Section 1, "Basic Knowledge and Practices", is directed to the industrial waste engineer. Topics covered include the effect of wastes on streams and waste-water treatment plants, stream protection measures, computation of organic

waste loads on streams, stream sampling, and the economics of waste treatment. The approach is a very "how to" one and Nemorow provides careful detailed explinations of the techniques involved.

Section 2, Theories, is directed to a broader audience and provides a very straightforward, informative review of some standard waste treatment theories, along with an interesting look at some new ideas - such as neutralization, equalization and proportioning, and ways to remove inorganic dissolved salts.

Both these sections really serve as background to Section 3, Applications which provides a case study summary of various theories of separate versus joint (i.e., municipal-industrial) combined sewage systems . Several examples are provided under each option: joint treatment of raw industrial wastes with domestic sewage, joint treatment of partially treated industrial wastes and domestic sewage, discharge of completely treated wastes to municipal sewer systems, discharge of raw wastes to streams, discharge of partially treated industrial waste directly to streams, discharge of completely treated wastes to streams, and site selection techniques. The emphasis here is on engineering practice, which translates to mean an examination of engineering theories as they interract with economic conditions, political considerations, etc. Finally, in Section 4, Major Industrial Wastes, Nemerow provides a valuable review of the waste problems in six industrial sectors: the apparel industries, food processing industires, the materials industries (wood fiber, metal, liquid metal, etc.), chemical industries, energy industries, and radioactive wastes. Almost one half of the entire book is devoted to this last section and it is surely one of the most well-organized and informative summaries of the sources of industrial wastes in print. An extensive list of references is appended to each chapter and, while many of the works cited date from the late fifties and early sixties, they should provide some useful information in themselves and, more importantly, can guide the reader to those publications and organizations which routinely provide information on

industrial wastewater topics. In short, this is an excellent introductory reference, one that should prove useful to students and practicing engineers alike.

2. ENVIRONMENTAL SIDE EFFECTS OF RISING INDUSTRIAL OUTPUT

Author: Edited by Alfred J. Van Tassel, Hofstra University.

Publisher: Heath Lexington Books, D.C. Heath & Company, Lexington, Massachusetts (548 pp.) 1970.

Point of View: "It has become evident that the vast expansion of output in recent years has had profound repercussions on the quality of the American environment, and it is reasonable to suppose the enormous increase in the GNP projected by RFF could have proportional impacts. These environmental side effects were given no more than passing mention by RFF in its study . . . . The present study seeks to supplement the RFF study by exploring the implications for the quality of the environment of the RFF projections."

Level: Non-technical; numerous tables, graphs and diagrams; bibliography.

Summary: In 1963 Resources for the Future published a landmark study of the U.S. resource base and of the resources which would be needed to sustain uninterrupted growth of the economy from 1960 to 2000. That study, Resources in America's Future, was adopted as a symposium topic by the Hofstra University School of Business and this book, edited by an Associate Professor of Business Research, reports the findings of that symposium as to the environmental implications of the RFF growth projections. It is a broad based survey, dealing with a wide sampling of industrial waste practices in the major U.S. industries.

An overview paper by Van Tassel, "The Environment and Rising Output: Methodology for a Study", introduces the volume and outlines the approach taken by the symposium participants. A brief explication is provided of the RFF projection figures and of the limitations which must be placed on their

interpretation. This is, of course, not meant to substitute for the reader's examination of the original RFF study and is simply a brief summary to set the papers which follow in context.

Several of those papers (Chapters 2-5) are directly applicable to the topics in this water pollution bibliography and all are of sufficient bearing to recommend careful reading of this book in its entirety. Topics addressed include "The Social Costs of Expanding Paper Production", "Water Pollution and Expanding Production in the Steel, Chemical and Petroleum Industries", "Thermal Pollution", "The Social Costs of Surface Miend Coal", and "Eutrophication and Nutrient Sources". Excellent data summaries accompany each of these papers, many in the form of easy-to-read tables and graphs, amking this an invaluable resource document for the study of industrial pollution problems. In the final chapter, "Summary of Findings", Van Tassel provides a review of the major findings reported in each paper and provides some general, overall conclusions as to the environmental impact of industrial wastes and the economic realties of correcting the major problems.

Additional data and technical backgroudn material is provided in a series of eight appendices and the reoort concludes with a chapter by chapter bibliography which provides reference to several hundred books, periodicals and govennrnment reports, all directed to problems of industrial wastes and their control.

### 3. WASTE DISPOSAL PROBLEMS IN SELECTED INDUSTRIES

Author: Edited by John E. Ullmann, Professor of Management and Chairman, Department of Management and Marketing and Business Statistics, Hofstra University.

Publisher: Hofstra University Yearbook of Business, Series 6, Volume 1 (284 pp.; 1969.

Point of View: "This report presents a series of studies of the waste disposal problems and practices in several manufacturing industries. It attempts to assess the adequacy of present procedures and the task of providing for the future. Specifically, it tests the hypothesis that the technical problems in waste disposal are largely solvable but that the implementation of effective practices is beset by managerial and institutional impediments and by some major shortcomings in present abatement legislation".

Level: Non-techincal: numerous tables and diagrams.

Summary: This is the predecessor of Environmental Effects of Rising Industrial Output and despite its 1969 publishing date, it remains an excellent companion earlier to that / work and an important contribution to the industrial waste problem literature. It, too, is the product of a Hofstra School of Business Seminar, with individual papers contributed by eight students and a final review paper by Ullmann.

"The Slaughtering House and Rendering Industries" are examined in chapter 1 and a careful review is provided of the technical advances in pollution control within the industry and their managerial and economic implications. Specifically, the author examines the various processes which cause pollution, the managerial and legal aspects of waste treatment controls, and the costs and technology of the abatement techniques available. The author concludes that:

> Basically it is the economics of not having the money or not wanting to spend it on pollution abatement . . . Therefore it is economic and managerial problems that are the impediments to the alleviation of environmental

> damage caused by the slaughterhouse and rendering industries rather than the technical problems which have already been solved.

Related food processing waste problems are examined in Chapter 2, "The Duck Industry of Long Island", which provides a good overview of the relationships between these poultry process wastes and the pollutional problems encountered by the nearby shellfish industry. Sepcial emphasis is directed to the existing legal constraints on the duck industry and on the problems of their enforcement. The author concludes that "the local officials have not been decisive in pressing for solutions and the law enforcement process has been bogged down in jurisdictional disputes."

Chapter 3, "The Shipping Industry" introduces the problems of oil pollution and the complex international laws and regulations which attempt to bind the shipping industry. Again the conclusion has a familar ring:

> Currently developed techniques can eliminate up to 95 percent of the water pollution associated with the transportation of oil by ocean tankers only if they are conscientiously adhered to by ships' masters and crews . . . . The overwhelming evidence thus indicates that any sea pollution by oil can be brought under control, but it must be evident that any suggestions for pollution abatement are merely alternatives to complete prohibition of discharge, a very probable requirement of the future.

In chapter 4 similar review is provided of the heavy chemical industry with specific attention to four pollution categories: dissolved inorganic salts, dissolved orgainc chemical wastes, acids and alkalies, and toxic materials. Managerial, economic, legal and technical factors are examined in turn. The conclusion for this industry is not as straightforward but, again, the main impediment to improvement seems to be the lack of economic incentive.

The story is a similar one in the two chapters which follow: "The Steel Industry" and " Pollution in the Nonferrous Metals Industry". The former paper provides a useful review of the processes involved in steel making,

but it fails to provide a substantive conclusion, calling instead for increased awareness on the part of management to existing pollution problems. In a similar way, the author of the paper on the nonferrous metals industry is mainly concerned with the processes involved and focuses most of his concluding remarks on possible economic incentives (tax exemptions, etc.) and on problems with the existing permit system.

Two "power and energy" industry papers follow: "Waste Disposal Problems of Power Stations" and "Radioactive Waste Management in Industry". The former concentrates on air pollution problems associated with fossil fuel plants and the technology available for controlling fly ash emission. Only passing mention is directed to the problems of thermal pollution. Some attention is given in the radioactive waste paper to coolant water contamination, but the major focus is directed to the problems of siting and containment, with some mention of sea disposal of radioactive waste.

Ullmann, in the reports summary chapter, provides the following conclusion:

> It was the objective of this report to consider one central question: are the impediments to effective pollution control technical or are they largely managerial and economic? . . . In every case, the technology exists for alleviating most if not all of the pollution which is caused. . . . The problem in dealing with pollution rather appears to be the same ones which observers have always noted: that of setting stringent standards of cleanliness and effluent purity and proper law enforcement to see that these standards are maintained.

4. INDUSTRIAL WASTE PROFILE S

Author: U.S. Department of the Interior, Federal Water Pollution Control Administration.

Publisher: Volume III of The Cost of Clean Water, U.S. Department of the Interior, FWPCA (10 volumes; 100 pp. each) 1967.

Point of View: "The Industrial Waste Profiles were established to describe the source and quantity of pollutants produced by each of the ten industries studied. The profiles were designed to provide industry and government with information on the costs and alternatives involved in dealing effectively with the industrial water pollution problem."

Level: Semi-technical; descriptive summary plus background data in tables and graphs; bibliography.

Summary: Despite a 1968 publishing date, these ten reports remain one of the most comprehensive, single source references available on the dimensions of the industrial water pollution problem. Part of the "National Requirements and Cost Estimate Study" required by the Federal Water Pollution Control Act, they provide a wealth of information on the kinds of pollutants associated with the various industries, descriptions of the costs and effectiveness of alternatives, less polluting processing methods, evaluations of treatment technology and estimates of the water reuse potential of each industry.

While the EPA has updated much of this information with the publication of specific industry studies in its water pollution research series, this study remains a classic reference in the literature.

Profile number one, "Blast Furnaces and Steel Mills" provides examination of manufacturers of hot metal, pig iron, silvery pig iron and ferro-alloys from iron ore and iron and steel scrap; convertors of pig iron, scrap iron, and scrap steel into steel; companies engaged in hot-rolling

steel into basic shapes (plates, sheets, tubing, etc.) and merchant blast furnaces and by-product or beehive coke ovens. A brief summary section is followed by specific sections on processes and wastes, gross waste quantities before treatment or other disposal, waste reduction practices, and waste reduction or removal costs. A sixty-eight item bibliography is appended.

Profile number two, "Motor Vehicles and Parts" provides a pollution profile for the motor vehicle and motor vehicle equipment industry. An opening summary section provides an overview of the magnitude of the automotive industry's waste problems. Detailed examination is then provided on two aspects of the industry: stamping, body assembly, final assembly, and parts and accessories. Topics reviewed include processes and wastes (description of processes and pollutants), gross waste quantities before treatment or other disposal, waste reduction practices, and waste reduction or removal cost information.

Paper mills (except building) are the subject of profile number three, an especially well-illustrated treatment complete with numerous drawings and process flow diagrams. Principal areas of discussion are: the fundamental manufacturing processes and significant water and gaseous wastes generated by each operation, process water use and reuse, waste quantities and characteristics, waste reduction practices and their effectiveness, and waste treatment costs. Some interesting projections are provided on the state of the art which will be prevalent in 1977.

Profile number four deals with textile mill products. Again, a brief summary section provides an overview of the study findings, conclusions, and limitations. Three specific areas are examined: wool textile weaving and finishing; cotton textile finishing; and synthetic textile finishing.

For each area, information is provided on processes and wastes, gross waste quantities, waste reduction processes, and costs for facilities, processing and treatment. Individual area bibliographies are provided for each section and a general bibliography and glossary is appended.

Petroleum wastes are examined in profile number five. The focus here is on the refining industry (not the production of crude oil or natural gas) and the discussion is organized under six main headings: fundamental processes, water use and reuse, manufacturing process utilization, waste quantities and characteristics, waste reduction practices, and waste treatment costs. Again, numerous graphs, tables and diagrams are included; in fact, the information in this report is evenly divided between the descriptive text and the technical information in the appendices.

Profile number six, canned and frozen fruits and vegetables, is one of three food processing profiles in the series. The canning and freezing industries are examined separately under four main topics: processes and wastes, gross waste quantities, waste reduction practices, and cost information. It is a most readable summary, again, complete with bibliography and extensive background data.

Leather tanning and finishing, profile number seven, is one of the shorter volumes in the series. The same general topic outline is utilized here, but a major difference is reflected in the future outlook sections which predict a continuing decrease in the size of this industry and in its impact on the environment.

With profile number eight, meat products, the study turns to an examination of two large industries: meat packing and poultry processing. These are dealt with separately under the standard headings: fundamental industry processes, gross pollution quantities and pollution reduction schemes and costs.

The last food processing volume in the series is profile number nine, dairies, in which five industry subdivisions are examined: creamery butter, cheese (natural and processed), condensed and evaporated milk, ice cream and frozen desserts, and fluid milk. While the same topic outline is employed here, the text discussion is unusually sparse and the reader is asked to spend most of his time interpreting various tables and graphs. That makes this a good data reference but a less rewarding volume than most of the others in terms of a good, overall descriptive summary of the industry problems.

Finally, profile number ten provides an examination of plastics materials and resins. Again, this is a fairly technical treatment which relies heavily on tables, flow diagrams and financial cost analyses. It is a very straightforward report with a brief summary section followed by nine specific materials chapters: cellulosics, vinyl resins, polystyrene resins and copolymers, polyolefins, acrylics, alkyl and polyester resins, urea and melamine resins, phenonolic resins, and miscellaneous resins. There is no bibliography included here and it is unlikely that this volume will appeal to the general reader.

II. MAJOR INDUSTRIAL USES OF WATER

A. Water for Power and Energy

1. Thermal Pollution: Status of the Art

Authors: Frank L. Parker, Peter A. Krenbel, Dept. of Environmental and Water Resources Engineering, Vanderbilt University.

Publisher: National Center for Research and Training in the Hydrologic and Hydraulic Aspects of Water Pollution Control (432 pp., $6.00) U.S.E. P.A. (PB-216 716) December, 1969.

Point of View: A survey of research on thermal pollution. The treatment is satisfactorily objective.

Level: For the specialist, but some chapters will be useful and readable for the non-specialist.

Summary: This is a state-of-the-art report on thermal pollution. The major emphasis is on the central electicity generating plant. The report consists of twelve chapters and an appendix, while all the chapters are fairly technical and assume some familiarity with the terminology of water heating and its effects, the chapters themselves vary greatly in their level.

The first five chapters serve as an introduction to thermal pollution, its causes and effects. In Chapter 1, the present and projected cooling water requirements from central plants are discussed and this is supplemented by discussions of alternatives to central power station generation and alternative methods of heat dissipation. Chapter 2 summarizes briefly the physical, biological and chemical effects of heat and water. Chapter 3 reviews the effects of temperature in aquatic organisms. In Chapter 4 the effects of thermal discharges in water quality and in its ability to assimilate waste is treated while Chapter 5 briefly reviews the various beneficial effects of warming.

The next three chapters are very technical and of interest only to the water engineer. They deal with prediction of heat dissipation, the

mechanisms of heated water discharges and with mathematical modeling of heated discharges.

Chapters 9, 10, 11, and 12 are again accessible and of interest to the non-specialist and deal with cooling techniques. Chapter 9 briefly surveys cooling ponds and straight through cooling. In Chapter 10, the authors describe the different types of cooling towers, and their environmental difficulties are reviewed in Chapter 11. The last chapter compares the cooling methods as to climatic requirements, operation and costs. The appendix presents the results of a study of temperature effects in salmon. Each chapter ends with a brief presentation of research needs and a bibliography.

This report is most useful for its completeness; the whole steam electric thermal pollution problem is surveyed. It is now somewhat dated, but no similar recent study is available and this one remains a desirable background document

2. ACID MINE DRAINAGE IN APPALACHIA

Author: Appalachian Regional Commission and Committee on Water Quality Management-Panel on Mine Drainage Pollution Control of the National Research Council-National Academy of Sciences-National Academy of Engineering.

Publisher: U. S. Government Printing Office, House Document #91-180, 91st Congress, 1st Session, 1969.

Level: Volume 1 of this 3-volume series is semi-technical in its presentation, while the second and third volumes present specific aspects of the overall topic in much greater detail.

Point-of-View: Description of problems and appropriate control measures.

Summary: This study of acid mine drainage in Appalachia was carried out in accordance with the provisions of the Appalachian Regional Development Act of 1967. It is reported in three volumes. Volume 1, Acid Mine Drainage in Appalachia, is the summary report, while the other two volumes present Appendices. Volume 2 contains Appendix B, Engineering Economic Study of Mine Drainage Control Techniques, and Appendix C, The Incidence and Formation of Mine Drainage Pollution in Appalachia. Volume 3 contains: Appendix D, The Impacts of Mine Drainage Pollution on Location Decisions of Manufacturing Industry in Appalachia; Appendix E, Mine Drainage Pollution and Recreation in Appalachia, and Appendix F, The Biological and Ecological Effects of Acid Mine Drainage. Appendix A, The Impact of Mine Drainage Pollution on Industrial Water Users in Appalachia is in Volume 1.

While the Appendices will provide valuable detailed data for anyone making a thorough analysis of the effects of acid mine drainage in the Appalachian region, the summary of Volume 1 will probably be sufficient for anyone who is concerned with this topic as a part of a larger problem, such as water pollution or energy production.

Volume 1 itself opens with a 13-page summary, "Findings and Conclusions," and then devotes 10 to 20 pages each to the topics:

1) Sources and Occurrence of Mine Drainage.

2) Acid Mine Drainage Abatement and Control Techniques.

3) Impact of Mine Drainage Pollution on Industrial Users and Utilities.

4) Mine Drainage Impacts on Navigation and Public Facilities.

5) Impact of Mine Drainage on Recreation and Stream Ecology.

6) Program Considerations.

These six chapters provide useful information on what acid mine drainage is, where it comes from, what it does and what can be done about it. While some of the information is quite general, there are a host of specific instances and case studies provided. Of particular interest are the estimates of the economic costs of mine pollution to various activities, and of the costs and savings of various control programs.

The study is an excellent source of quantitative data on all aspects of acid mine drainage in Appalachia and includes many tables and illustrations, including detailed maps of the affected regions in Appalachia.

Although it now must be considered somewhat out of date, the study provides both baseline data and important background reading in the area of water pollution from coal mining. It is written at a level which makes it understandable to science teachers and to students who have some background in the sciences.

3. POWER GENERATION AND ENVIRONMENTAL CHANGE.

Author: Edited by David A. Berkowitz and Arthur M. Squires.

Publisher: The MIT Press, Cambridge, Massachusetts (440 pp.; $16.95 ) 1971. Symposium of the Committee on Environmental Alteration, American Association for the Advancement of Science.

Point of View:

> "Man's deisre for power must be reconciled with the needs of the environment. This book presents the many and varied relationships between power generation and environmental change and provides a basis for understanding the consequences of increased power generation capacity."

Level: The level varies from chapter to chapter, but the book is generally understandable by anyone with a scientific vocabulary equivalent to the college level introductory science courses.

Summary: This book is the outgrowth of a symposium of the same name held at the Annual Meeting of the AAAS in Boston on December 28, 1969. The book is a considerable expansion of the symposium presentation, including both expanded remarks from the symposium participants and additional chapters.

Even though this is really one of the basic references on the broad subject of energy and the environment, and not specifically a water pollution reference, Power Generation and Environmental Change is included in this bibliography because of the excellence of its chapters in thermal pollution of rivers and lakes. The book is divided into five parts: I., "Power, Man and Environment"; II., "Nuclear Power and Radionucleides in the Environment"; III., "Hydroelectric Power"; IV., "Fossil Fuel Power"; V., "Waste Heat".

Water pollution is briefly dealt with in the discussion of nuclear power (Part II) and the problem of acid mine drainage and its control are described in Chapter 18, "Environmental Aspects of Coal Mining," (Part IV). The important contributions to the understanding of water quality problems are, however, in Part III and Part V.

The two chapters of Part III, "Ecological Effects of Hydroelectric Dams,"Karl F. Lagler, and "Pumped Storage Hydroelectric Projects", David A. Berkowitz, summarize the full range of effects, but effects on water quality and aquatic life are, of course, the most improtant of these. Effects on general water and evaporation are also disucssed briefly.

The most improtant chapters, for those interested in water quality change, are those in Part V. In Chapter 19, "Environmental Quality and the Economics of Cooling", S. Fred Singer briefly summarizes the sources of thermal pollution and lists some of the more important effects of heat on water quality. This chapter also includes useful data on the costs of alternative cooling techniques.

The most useful chapter overall is "Impact of Waste Heat on Aquatic Ecology," in which Clarence A. Carlson, Jr., summarizes the effect of temperature on various categories of plant life. The remaining chapters of Part III, Chapter 21, "Thermal Effects--a Potential Problem in Perspective," by Walter G. Belter, Chapter 22, "Comments on the Use and Abuse of Energy in the American Economy", by Robert T. Jaske, and Chapter 23, "Alternative Technologies for Dishcarging Waste Heat" by William H. Steigelmann, have less relevance to water pollution. There are interesting facts to be gleaned from them, nevertheless. In Chapter 21, Belter presents data on the growth of electric generating capacity, fossil and nuclear, and the costs of various cooling technologies. Chapter 22 deals with overall energy consumption growth.

Chapter 23 returns again to the relations between waste heat and water and presents a useful comparison of the thermal pollution from nuclear and fossil-fueled plants. It also includes a good, terse presentation of comparative data on all of the important cooling technologies including land use, water requirements and cost per kw. This chapter presents a brief listing of the beneficial potential of heated water.

Power Generation and Environmental Change is a book that is likely to be on the back shelf of anyone who is interested in that broad topic. It will also be useful to the water specialist for its discussion of the uses of water for cooling power plants.

B. Production of Paper and Allied Products

1. STATE-OF-THE-ART REVIEW OF PULP AND PAPER WASTE TREATMENT

Author: Dr. Harry Gehm, WAPORA, Inc., 6900 Wisconsin Ave., N.W., Washington, D. C. 20015.

Publisher: Environmental Protection Technology Series, Office of Research and Monitoring, U.S. Environmental Protection Agency, Washington, D. C. (EPA-R2-73-184) April 1973 (253 pp.; $2.85).

Point of View: "This report sets forth the state of the art in the treatment of pulp and paper mill waste water as it stands in 1971. In order to lay a background for the sections on treatment, a review of both the general economic position of the industry as a whole and the major production processes is included."

Level: Semi-technical: numerous tables, graphs and diagrams: extensive documentation.

Summary: This report is one in a series of Environmental Protection Technology publications designed to "describe research performed to develop and demonstrate instrumentation, equipment and methodology to repair or prevent environmental degradation from point and non-point sources of pollution". Beyond the state-of-the-art information denoted in the title, the report provides a review of the water quality problems associated with pulp and paper industries, performance data on various treatment processes and systems, and a summary of the techniques used to monitor the discharge of wastes.

In short this is a very comprehensive document and contains materials of interest to both the general reader and to the professional.

Section one is introduced by a brief "Recommendation and Conclusions" section which addresses six areas: receiving waters, analyses, clarification, color, BOD Reduction, and Treatment and Disposal of Residues. As an overall

conclusion, the author notes the inadequacy of present practices in residue handling and disposal and recommends that, "it appears of major importance that all current (residue) studies be tabulated and evaluated as to their adequacy of approach to the overall problem so that the desirability specific areas of research, both basic and applied, can be established."

Much of the data reported in the chapters which follow was provided by state pollution control regulatory agencies and the EPA. (For an interesting examination of the problem of establishing a federal data bank in this area see "The Establishment of A National Industrial Wastes Inventory" Hearing before a Subcommittee of the Committee on Operations, House of Representatives, 91st Congress, 2nd Session, September 17, 1970 (Washington: USGPO) Y 4. G74/7:W28). Gehm begins with an examination of the "Productivity and Economics of the Industry" and provides a good selection of production data, facilities capacity, per capita consumption, employment, profits, and the economics of recycling. This is followed by an examination of the "Water Quality Problems of the Industry", a ten page discussion which includes discussion of the industry's use and re-use of water, problems of suspended organic matter, fiber leaching, effects on aquatic biology, heavy metals, and sewer losses of inorganic chemicals. All of these first four chapters are extremely informative, readable, and suitable for the reader with little or no background in this area.

The more technical material comprises the remaining chapters, although sections of these are quite straightforward and should be intelligable to the interested reader. Separate chapters are addressed to the processes employed for efficient management and treatment, advanced waste treatment, water reuse and reclamation, sludge handling, treatment and disposal, treatment in public facilities, and the origin of specific mill effluents and results obtained by treatment. In this latter chapter, Gehm examines a

variety of pulp and paper manufacturing processes and provides an excellent summary of what goes in the mill and how specific products are produced. Finally, Gehm examines the cost of treatment, and the effectiveness both of effluent testing procedures and of actual monitoring techniques.

Additional background data is provided in a series of nine appendices, An extremely useful bibliography, listing several hundred references, is included.

2. PAPER PROFITS: POLLUTION IN THE PULP AND PAPER INDUSTRY

Author: Leslie Allan, Eileen Kohl Kaufman, Joanna Underwood, et.al, The Council on Economic Priorities (CEP), New York, New York.

Publisher: The MIT Press, Cambridge, Massachusetts (504 pp.; $20.00) 1972.

Point of View: "As clearly revealed in this study, in practice the environmental impact of a chemical pulping plant simply reflects the effort made to recover the added chemicals (and the organic wastes from the wood itself) from the mill waste. And what determines this effort is the willingness of the operator to meet the costs of chemical recovery. There are, in effect, no natural or technological barriers to essentially complete control of pollution from such pulping plants."

Level: Non-technical: numerous tables; some illustrations; well documented.

Summary: This is CEP's first in-depth study in the environmental area and it reports the result of an eight month study into "the practices of the 24 largest pulp and paper makers, the pollution problems they face, and the pollution control steps they have taken." It is a fascinating report, written in a very readable style that combines informative discussion and careful documentation.

Part I, "Papermaking and Pollution", consists of five chapters which deal in several pages each with "The Pollutants of Pulping" (air pollution,

water pollution, and industry efforts), "The Pulping Processes" (groundwood, chemical, neutral sulfite, acid sulfite, and Kraft pulping), the State of the Art (effluent controls and treatment), "Pollution Control and the Law" and, finally, "The Study: Background and Major Results". This latter chapter serves to introduce Part II of the study, "The Twenty-Four Pulp and Ppaer Companies" in which individual profiles are provided on each producer. While these vary in length from company to company, they average about fifteen pages each and provide information on the companies products, finance, production figures, pollution record (by mill) and a pollution overview which summarizes the companys efforts to meet the legal,social and environmental restrictions placed on its operation.

A series of five appendices is included: Federal Criteria from the "Green Book", The Marlin-Bragdon Report, A Follow-Up Study (done in Dec. 1971), Index of Consumer Brands, and U.S. Deaprtment of the Interior Proceedings on Pollution of Interstate Waters. Finally, an eight page bibliography of books, magazine and trade journal articles, reports and government documents is included. All in all, this is a very interesting and informative account which takes a very different cut through this environmental problem than do most of the reports currently available.

II. MAJOR INDUSTRIAL USES OF WATER

C. Steel, Chemical and Petroleum Industries

1. ENVIRONMENTAL STEEL

Author: James Spenser Cannon, Council on Economic Priorities

Publisher: The Council on Economic Priorities, Washington, D.C. (523 pp.; $3.00) 1973.

Point of View: This is one in a series of reports on various industries done by the Council on Economic Priorities (CEP), "a non-profit organization dedicated to analyzing and performance of U.S. corporations in areas including preservation of the environment, employment of minorities and women, political influence, production for a peace time economy, and consumer practices."

Level: Non-technical; illustrated; numerous graphs, diagrams and tables; well documented.

Summary: Subtitled, "Pollution in the Iron and Steel Industry", this is an excellent summation of the kinds of environmental problems associated with the making of steel and the degree to which these problems impact on our well-being as a nation. It is an impressive report, the result of lengthy and detailed investigation and analysis, and it is a readable one, written in the kind of concise, narrative style which should appeal to a wide audience.

The first half of the reprot text (172 pages) provides an overview of the pollution problems in the steel industry and an explication of the design, me ods and findings of this particular study. Some extremely interesting and provoking data is presented in the first chapter, enough to more than whet the readers appetite for the more detailed findings which follow. These are all carefully documented and explained in terms of the impact of various pollutants, in terms both of dollars and damage to health and welfare. Those unfamiliar with the steel industry will be especially appreciative of the third chapter,

which provides a very readable and informative explanation of the steel making process. This is followed by two fairly lengthy chapters, one dealing with air pollution from steelmaking and the other with the industry's water pollution problems, especially those associated with arsenic and zinc discharges. Sources and effects of the various pollutants are explained, with separate sections addressed to oxygen consuming wastes, chemical oxygen demand, temperature, pH, and the toxic effects of specific materials: ammonia, cyanide, flouride, oil, phenol, sulfate and chloride, iron, and heavy metals (i.e., arsenic, cadmium, chromium, lead and zinc). This is followed by a section on water pollution control systems, in which the authors briefly review primary, secondary and tertiary treatment techniques and provide some comments on the special problems of thermal pollution sludge disposal, and the potential for recycling industrial wastewater. Recycling is a theme which is picked up again in Chapter 6, "Steel: The Recyclable Material", in which the authors argue strongly for a reduction in the production of new steel. The economics of this and related issues are explored in the next chapter, "Economic Impact of Pollution Abatement". While this is mostly presented in terms of tables and citing of various figures and statistics, the authors provide impressive and quotable narrative summaries to assist the non-economist:

> If the top seven steel producers were to pass the full cost of pollution control on to their customers in the form of higher prices, the average annual price increase per ton of steel necessary for the companies to come into compliance between 1972 and 1976 would vary from 1.0% to 1.2% a year. The latter increase, if it were again passed directly on to the consumer, would cause an annual price increase of less than $5.00 in the cost of an automobile containing two tons of steel.

Detailed statistical back-up for this and other conclusions presented in the body of the report is provided in the last chapter in part I: "Methods: Sources, Cooperation, and Criteria for Evaluations".

Part II of the study concludes the text narrative with individual close-ups on the seven largest U.S. steel manufactures: Armco, Bethlehem, Inland, Jones and Laughlin, National, Republic, and United States Steel. A profile of each is provided, including a summary of their annual production, the adequacy of their pollution controls, special problems with their respective local environments, and the legal status of their various plants. Full documentation accompanies each chapter. Finally, a brief glossary is provided, along with three appendices: "Economic Impact - CEQ Estimated Air and Water Pollution Abatement Costs"; "Economic Impact - the CEP Model"; and "The CEP Questionnaire". There is simply nothing in print to compare with the comprehensive review provided by this report, and it is especially valuable to have it all presented in such a readable format.

## 2. THE CHARACTERISTICS AND POLLUTIONAL PROBLEMS ASSOCIATED WITH PETROCHEMICAL WASTE

Author: Prepared by Engineering-Science, Inc./ Texas, Dr. Ernest F. Gloyna, Consultant and Dr. Davis L. Ford, Manager.

Publisher: U.S. Department of the Interior, Federal Water Pollution Control Administration, Water Pollution Control Research Series (98 pp.) February 1970 (PB 192 310).

Point of View: "The Water Pollution Control Research Reports describe the results and progress in the control and abatement of pollution of our Nation's waters. They provide a central source of information on the research, development, and demonstration activities of the Federal Water Pollution Control Administration, Department of the Interior, through in-house research and grants and contracts with Federal, State and local agencies, research institution, and industrial organizations."

Level: Technical; numerous tables and figures; bibliography.

Summary: Like most of the reports in this series, this is a brief, data laden, overview which provides a useful summary for the non-specialist and a valuable introduction for the professional who anticipates p rsuing a detailed study of the problem.

A very straightforward statement of research needs introduces the report. Growth projections for the industry are provided and recommendations are made as to the potential of such pollution abatement technologies as increased water reuse and particular emphasis is placed on the need to standardize the technique of wastewater analysis. Most importantly, however, the authors note that:

> For optimum wastewater management in the petrochemical industry, it is necessary to develop the wastewater treatment as an integral process of the overall plant. This necessitates the development of increased product and feedstock recovery, improved housekeeping, separation of noncontaminated wastes from waste streams, and separating concentrated nonsoluble or otherwise solid fractions near each source.

It is noted also that the use of this wastewater treatment could be reduced considerably by in-plant reuse of product waste streams and wastewater in general.

The seven chapters which follow provide the data and observations to support the study recommendations. A brief description of the industry is provided with particular attention to water use and projection, principal products and intermediates, petroleum raw materials, and projected growth of the petrochemical industry. This is followed by a survey of petrochemical wastes and a review of the pollutional effects associated with them. Several aspects of waste treatment and control are then discussed in terms of internal improvements, physical, chemical and biological treatment processes and "other methods of disposal" (dilution, joint industrial municipal treatment, etc.).

Finally, the economic aspects of pollution control in the petrochemical industry are reviewed. The authors conclude:

> It is possible for industry to experience direct economic return through water reuse and product recovery. In many instances, contaminants can be removed less expensively in the plant than at the treatment facility. These and other factors merit engineering and economic review, the implementation of which may produce a monetary return to industry.

A useful one hundred and twenty item bibliography is appended.

II. MAJOR INDUSTRIAL USES OF WATER

D. Agriculture

1. AGRICULTURAL WASTE MANAGEMENT, PROBLEMS, PROCESSES AND APPROACHES

Author: Raymond C. Loehr, Dept. of Agricultural Engineering, Cornell University.

Publisher: Academic Press, New York (576 pp., $39.50) 1974.

Point of View: This book attempts to place the agricultural waste problem in reasonable perspective, to illustrate engineering and scientific fundamentals that can be applied to the management of these wastes, to illustrate the role of the land in waste management, and to discuss guidelines for the development of possible waste management systems.

Level: Introductory engineering text; numerous graphs, tables and illustrations; extensive chapter references.

Summary: Loehr himself provides a good description of his book in the preface:

> This book presents a summary of the processes and approaches applicable to the solution of agricultural waste management problems. In the context of this book, agricultural wastes are defined as the excesses and residues from the growing and first processing of raw agricultural products, i.e., fruits, vegetables, meat, poultry, fish, and dairy products. Implications and possible management systems for crop production are also discussed. The book is intended as a bridge between theory and practice as well as between the many disciplines that are involved in agricultural waste management.
>
> Emphasis is placed on those processes that appear most adaptable to the treatment, disposal, and management of agricultural wastes. Fundamental concepts are followed by details describing the use of processes and management approaches. Examples in which the processes or approaches were used with agricultural wastes are included to illustrate the fundamentals as well as the dsign and operational facets. The references cited are not intended to be exhaustive. They were chosen because their data either illustrated the scientific or design fundamentals of a process or illustrated the application of specific processes to agricultural wastes.

In Part I, "The Problem," Loehr provides examination of current restraints (legal and social), changing practices in agriculture, the environmental impact of agricultural activities, and the characteristics of agricultural wastes.

Part II, "Fundamentals and Processes," comprises the bulk of the book and contains seven chapters: Biological Processes, Ponds and Lagoons, Aerobic Treatment, Anaerobic Treatment, Utilization of Agricultural Wastes, Land Disposal of Wastes, Nitrogen Control, and Physical and Chemical Treatment.

The final section, "Management Approaches," consists of one chapter on the various aspects of managment: government action, decision making, joint industrial-municipal cooperation, animal wastes, food processing wastes, cropping patterns and soil management, and education and research.

Each of the chapters is accompanied by an extensive list of references and an appendix, "Characteristics of Agricultural Wastes," provides background data on the physical and chemical properties of the various waste products. All in all, this is a very comprehensive and detailed treatment of agricultural waste management and it should provide the non-specialist with an excellent, informed introduction to a very important aspect of the industrial water pollution problem.

II. MAJOR INDUSTRIAL USES OF WATER

D. Agriculture , Cont'd

2. POLLUTION IMPLICATIONS OF ANIMAL WASTES-A FORWARD ORIENTED REVIEW.

Author: Dr. Raymond C. Loehr

Publisher: Prepared for the Office of Research and Monitoring, U.S. Environmental Protection Agency, Water Pollution Control Research Series (E.P.I. 16:13040-07/68), Reprinted June 1973 (148 pp.; $6.00) 1973.

Point of View: "A state-of-the-art of literature on animal waste research and an overview of the problem associated with environmental vitiation resulting from confinement of all types of animals. This report is the initial review of the problem as it existed in 1968. Research recommendations and management practices current to its time are included in this document."

Level: Semi-technical; numerous tables and graphs; bibliography.

Summary: Originally published in 1968, this report has met with such enthusiastic acceptance that it was reprinted in 1973 and remains a standard reference on the topic of animal waste management. As is noted in the preface:

> Pollution Implications of Animal Wastes-A Forward Oriented Review will continue in use as the common basis for research, development, and demonstration of solutions to environmental problems relating to animal waste management until such a time as the state-of-the-art is sufficiently developed to warrant reevaluating and updating the total approach to the solution of these problems."

Parts 1 and 2, a set of summary recommendations and rationale for the study, introduce the report. The Chapters which follow summarize the current body of knowledge, indicate major problem areas, suggest feasible research and development applicable to the solution of the problem, and identify legislative, educational and technical areas needing further emphasis. Part 3, "Trends in Animal Production," deals with patterns of

meat consumption, livestock inventory, and production units. Part 4, "Manure Production," provides a general overview along with specific sections addressed to the effect of ration, physical and chemical characteristic, population equivalents, and the magnitude of the problem. Part 5, "Pollution Hazards," looks specifically at the problems of organic and inorganic pollution and health effects. Part 6, "Waste Treatment and Disposal," includes information on anaerobic and aerobic digestion, anaerobic lagoons, anaerobic-aerobic systems, land disposal, incineration and drying, miscellaneous processes and European practice.

Part 7, "Cost," looks at animal production costs and profits, animal waste treatment cost, treatment process cost comparison, and evaluation of compared processes. Part 8, "Legal," looks at Federal, State and Local law and briefly reviews the river pollution laws in Great Britain which have led to better regulatory control than those which exist in the U.S. Section 9, "Summary and Recommendations," concludes:

> The public must understand that waste disposal, including that from animals, is worth whatever it costs within the framework of sound administration and engineering. The cost is part of the price that must be paid for our high standard of living.

The text is well illustrated throughout with useful diagrams and tables and an extensive pre-1968 bibliography is appended.

3. AGRICULTURAL PRACTICES AND WATER QUALITY

Author: Ted L. Willrich and George E. Smith.

Publisher: The Iowa State University Press, Ames, Iowa (415 pp.; $8.50) 1970.

Point of View: "The materials contained in this volume should be both informative and useful. It was assembled by knowledgeable scientists, representing many disciplines, to identify the role of agriculture in clean water; more specifically, to present and evaluate the existing body of

facts as they identify agriculture's contribution to polluted water and reveal alternative solutions to provide clean water."

Level: Semi-technical; numerous graphs, tables, and diagrams; chapter references.

Summary: In 1964, passage of the Water Resources Research Act provided for the investigation of water problems through organizations at the land-grant universities. This volume grew out of a 1968 discussion, "Pollution of Water by Agriculture," held at a regional meeting of the organization directors and research workers from state universities in the Midwest. It was decided that the topic would be of increasing interest and that input was needed from a variety of disciplines in order to gain a broad-based perspective on the problem. A regional conference was planned and held at the Iowa State University, and this book reports those proceedings. Major topics were isolated for discussion and four or five papers were contributed under each. The topics are:

1) Sediment as a Water Pollutant.
2) Plant Nutrients as Water Pollutants.
3) Pesticides as Water Pollutants.
4) Animal Wastes as Water Pollutants.
5) Agricultural Production Implications.
6. Agriculture's Involvement in Polluted and Clean Water.

The volume is introduced by a very informative and readable review paper: "Issues in Food Production and Clean Water." One of the major aims of these proceedings is to provide "fundamentals and established research facts...at a level that could be understood by representatives from other disciplines." For the most part, the authors have succeeded in meeting those criteria and the non-specialist should find this a useful and informative treatment of the water pollution problems associated with agricultural activities.

II. MAJOR INDUSTRIAL USES OF WATER

E. Other Industries

1. STATE OF THE ART OF TEXTILE WASTE TREATMENT

Author: A study conducted for the EPA Water Quality Office by the Department of Textiles, Clemson, University, Clemson, South Carolina

Publisher: Water Pollution Control Research Series, Water Quality Office, Environmental Protection Agency, (348 pp.; $2.50) 1971.

Point of View: This is the report of a study of waste treatment methods and practice in the textile industry, "designed to give the reader an insight into the problems facing the textile industry, solutions presently available, and references for further reading".

Level: The data presentation in charts, graphs and tables is complete and technical. The text is descriptive and accessible to the non specialist scientist or engineer.

Summary: This report gives a concise and well organized review of textile water pollution problems and control practices. The narrative part of the report occupies only a third of the total pages; the other two thirds are given over to Appendices.

As is common for EPA reports, the first section is an eight page summary of the conclusions and recommendations which is largely given over to brief suggestions of areas of needed research.

The body of the report begins with an Introduction. in which the important general processes in textile production (sizing, scouring, merariging, bleaching, etc.) are briefly described and changes over the years noted. This is followed by four chapters: The Characterization of Textile Effluents, Review of Waste Treatment Techniques, Treatment of Textile Effluents, and Cost of Treatment Processes.

The chapters are short, 15-25 pages in length, and each concludes with a short summary. The chapter on textile effluents briefly describes the

steps in textile processing as well as the contributions to the waste stream of each step. The chapter on waste treatment similarity provides a brief review of waste water treatment processes while the following chapter describes the specialized problems and olutions of textile waste. The last chapter examines the costs of these various procedures.

The body of the report is written in a terse and not very interesting style. It will be read with most profit by those who already know something about water treatment and need a quantitative introduction to the problems that textile wastes add.

The appendices which comprise the remaining two thirds of the report are a pot pouri of information. The first reviews state and federal legislation. The second, Appendix B, is a voluminous annotated bibliography of 70 pages, while C lists the agencies etc. contributing to the study and D reports some data from measurements made in streams and rivers above and below some (unidentified) plants.

Generally the report will best serve as an outline of textile waste problems. It is not written for popular consumption and will be of most use to the teacher who wants to produce material to fit into a broader presentation or to the water treatment specialist who will benefit from the thorough presentation of data.

2. PROCEEDINGS, SECOND NATIONAL SYMPOSIUM ON FOOD PROCESSING WASTES

Author: Symposium cosponsored by Pacific Northwest Laboratory, EPA, and National Canners Association.

Publisher: EPA Water Research Control Research Series, EP1.16:12060-03/71 (USGPO stock # 5501-0167; 664pp; $4.50) 1971.

Point of View: This is the report of one in a planned series of conferences to discuss current research on treatment of food processing wastes. New waste treatment research is reported on, along with a discussion of air pollution and solid waste programs!

Level: Technical; varies from paper to paper, but generally some previous familiarity with the topic under discussion is assumed. Numerous tables, graphs, and illustrations.

Summary: The food processing industry is so large and varied that it is difficult to find a single reference which will introduce a reader to the field in general. This yearly symposia, however, cosponsored by the Federal government and industry associations, provide a kind of state of the art review of a wide range of food processing waste problems.

The 1971 conference report, for example, provides an overview paper on the environmental quality concerns of the food processing industry. Various concerns of the industry are isolated for discussion, with a focus on the industry-government interface. This is followed by a brief explanation of the EPA's Industrial Pollution Control Program and of the implication for the industry contained in the Clean Air Amendments of 1970 and various government solid waste management initiatives. Individual papers are then included, each addressed to the problems of a specific aspect of the industry: shellfish, cannery wastes, frozen fruit and vegetables, potato starch, corn and pea processing, citrus waste, meat packing waste, poultry processing, dairy product processing, and beet sugar wastes. Additional papers examine pollution problems of a more generalized nature: solid waste management, salt reclamation from food processing brines, reduction of salt content of liquid waste effluent, biological and trickling filter treatment of waste waters, recovery of fatty materials, anaerobic-aerobic treatment ponds, etc. In short, a wide range of problems are briefly touched on here, providing a good overview introduction for the interested reader.

3. PROCESSES, PROCEDURES, AND METHODS TO CONTROL POLLUTION FROM MINING ACTIVITIES

Author: Report prepared by Skelly and Loy, Engineers--Consultants, Harrisburg, Pennsylvania and Penn Environmental Consultants, Inc, Pittsburgh, Pennsylvania

Publisher: U.S. Environmental Protection Agency (EPA-430/9-73-011) October 1973 (389 pp; $3.40). Available from USGPO.

Point of View: "This report provides information on processes, procedures, and methods to control pollution resulting from mining activities. The control methods included in this report are identified and described by way of a brief text, generalized illustrations, and unit cost indications where possible. An extensive bibliography is appended with appropriate referencing in the description of each pollution control method."

Summary: Designed to provide a general overview of available pollution control techniques for mining activities, this report is mainly focused on coal mining pollution problems in the Eastern United States. A brief introductory section provides discussion of mining and water pollution problems in general and of the various pollution control techniques currently available. This is followed by a three part manual directed to an examination of surface mining, underground mining, and treatment. For the most part, the focus is on "at source techniques, those which can be utilized at the mine site and which generally involve a single capital expense and low or zero operating and maintenance costs."

Evaluation of each technique is provided, although no attempt has been made to provide extensive data or field-study results on any particular technique. Rather, the reader is referred to an extensive list of references which provide specific and detailed information. In addition, cost data on the various techniques is provided when available, but the authors emphasize

the variable nature of costs depending on the specifics of each situation. Some guidance as to the legal considerations in choosing one technique over another is provided, but again this is necessarily a very generalized treatment and the reader seeking detailed discussions should search the bibliography appended to the report for suggestions of other references.

Specific surface mining aspects considered are: Controlled Mining Procedures, Water Infiltration Control, Handling Pollution Forming Materials, Waste Water Control, Regrading, Erosion Control, and Revegetation. Underground mining topics include: controlled mining procedures, water infiltration control, waste water control and mine scaling. And, under "treatment," the authors review neutralization processes, neutralization with limestone, neutralization with lime, sludge disposal, evaporation processes, reverse osmosis, electrodialysis, ion exchange processes, freezing (crystalization) and iron oxidation. A glossary and two-hundred item bibliography is appended.

4. MINERAL MINING AND PROCESSING INDUSTRY, DEVELOPMENT DOCUMENT FOR INTERIM FINAL EFFLUENT LIMITATIONS GUIDELINES AND STANDARDS OF PERFORMANCE

Author: Prepared by the Effluent Guidelines Division, Office of Water and Hazardous Materials, U.S. EPA.

Publisher: U.S. EPA (EP1.8/3:M66/v. 1,2,3) October 1975 (Vol 1--280pp; Vol II--278pp; Vol III--228pp)

Point of View: These three documents present the findings of an extensive study of the mineral mining industry for the purpose of developing effluent limitations guidelines for existing point sources and standards of performance and pretreatment standards for new sources.

Level: Technical; numerous tables, graphs, and illustrations; glossary and bibliography appended to each volume.

Summary: These three volumes provide an excellent summary treatment of the pollution problem in the mineral mining industry. They are addressed

specifically to minerals for the construction industry (volume I), minerals for the chemical and fertilizer industries (Volume II), and clay, ceramics, refractory and miscellaneous minerals (Volume III).

An abstract of each volume is provided to outline the general report approach. This is followed by a statement of the study conclusions and recommendations. The body of each report is then addressed to the following topics: Introduction, Industry Categorization, Water Use and Waste Characterization, Selection of Pollutant Parameters, Control and Treatment Technology, and Cost Energy and Non-Water Quality aspects. Effluent reduction possibilities are then examined from two viewpoints: reduction attainable through the application of the best practicable control technology currently available, and reduction attainable through application of the best available technology economically achievable. Finally, new source performance standards and pretreatment standards are discussed. A great deal of useful information and data is included here and, while it is difficult reading for the nonprofessional, it does provide a good single source reference on an important area of industrial water pollution.

## III. OIL SPILLS: A SPEICAL CASE

### 1. OIL SPILLS AND THE MARINE ENVIRONMENT

Author: Donald F. Boesch, Carl H. Hershner, Jerome H. Milgram

Publisher: Ballinger Publishing Co. Cambridge, Mass. (114 pp.; $8.00 ) 1974.

Point of View: From the forward by McGeorge Bundy Pres., The Ford Foundation: "We do commend this report to the public as a serious and responsible analysis which has been subjected to review by a number of qualified readers . . . The matters it addresses are of great and legimate interest not only to those who are investing heavily in refineries and other petroleum producing and shipping facilities, but also to those who live and work in the areas potentially affected by oil pollution . . ."

Level: Semi-technical, the presentation assumes some familarity with scientific terminology. Most topics are introduced and defined at a level that would make them understandable to a college student.

Summary: This is one of the reports of studies which were commissioned by the Energy Policy Project of the Ford Foundation. It consists of a brief introduction and two papers of approximately equal length.

The first paper, Part 1, "The Ecological Effects of Oil Pollution in the Marine Environment" is by Donald F. Boesch and Carl H. Hershner, marine biologist at the University of Virginia. Part 2, "Technological Aspects of the Prevention, Control, and Cleanup of Oil Spills" is by Jerome H. Milgram, a hydrodynamic engineer at M.I.T.

These two parts are quite different in style as well as content. Part 1 is for the most part a qualitative description of the ecological effects of oil spills and of some of the methods and materials used to clean up the spills. Its major chapters are "Properties of Oil", "Effects of Oil in Marine Ecosystems", "Effects of Cleanup Techniques", and "Long Term Effects". Since

Part 1 is, in all, only 46 pages long individual topics can be treated only briefly but none-the-less, the fate of oil spills on the sea, its effects on birds and sea mammals, fish, plankton, intertidal and seabed organisms are all helpfully summarized and often illustrated with data from actual oil spills.

The authors emphasize the great degree of uncertainty which must accompany all statements about the effects both of oil spills and cleanup techniques and conclude with a brief resume of useful directions of con tinuing research.

Part 2, 49 pages long, is much more quantitive and technical and contains some useful tabular and graphical collections of data. The major chapters of Part 2 are "Spill Prevention", 'Cleaning Up", and "Critical Areas in Need of Research". These are preceeded by an introduction which presents and interprets some of the data on worldwide sources of oil pollution.

The two central chapters on preventing spills and cleaning up are quite specific and handbook like. The chapter on prevention deals not only with technical preventive measures but with ways to reduce the occurance of human error. Careful handling of oil at the dock as well as at sea is emphasized.

There is some overlap between Part 1's Chapter "Effects of Cleanup Techniques" and Part 2's "Cleaning Up". Part 1 emphasizes caution and the danger of introducing new elements into poorly understood ecological chains. Part 2 is much more the engineering "here's how to do it" approach. A specific example is provided by the contrasting views on the use of sinking agents, such as chalk: From Part 1: ". . . from the biological viewpoint it appears to be among the least acceptable countermeasures"; From Part 2: "In light of the apparently outstanding success of sinking oil with chalk off Brittany, surprising little information is available about this method". Part 2 also concludes with some suggestions of areas in need of research.

This brief book continues the high standard of products from the Ford Energy Policy Project. It will prove readable and rewarding to the non specialist environmentalist but at the same time there is sufficient scientific analysis, citation of research results pinpointing uncertainties along with extensive bibliographies, to profit the professional.

2. OIL POLLUTION: PROBLEMS AND POLICIES

Author: Edited by Stanley E. Degler

Publisher: Bureau of National Affairs, Washington, D.C. (142 pp.) 1969.

Point of View: This is a collection of independently written papers and the point of view varies. All reflect, however, the governmental and private concern that followed the "Torey Canyon" disaster.

Summary: This booklet is mainly of historic interest, but it is capable of sustaining that interest. It consists of three papers and a collection of other (now historical) documents.

The first of the papers, "Oil Pollution at Sea" is by John O. Ludwigson, a free lance science writer. Briefly, and in a popular style, he sumarizes the recent history which at that time included the Torey Canyon wreck off the Coast of England and the wreck of the Ocean Eagle in the port of San Juan, PR. The recounting of the timetable of these wrecks and their aftermath is a useful resource. This author also summarizes the state of the art of prevention and cleanup, but this is better done in newer references (See for instance: "Oil Spills and the Marine Environment", Reference 1 above).

The second chapter "Oil Pollution and the Law" was written by Max N. Edwards, then an Assistant Secretary of the Interior for Water Pollution Control. This piece is even more dated and consists of an address to the

"International Conference on Oil Pollution at Sea" held in Rome, in October 1968.

The chief interest in this article is in its summary of the existing legal situation in 1968 and its proposal for an International Convention on maritime pollution.

The Third chapter, "Oil Spillage Prevention, Control, and Restoration - State of the Art and Research Needs" is written jointly by W.H. Swift, C.J. Tonhill, and W.L. Templeton of Battle Memorial Institute and D.P. Roseman of Hydronautics Inc., Laurel, Md. It is, as advertized,a brief state of the art resume of causes, effects, control and prevention.

The remaining items are (1) a "Report to the President" released in March 1968 which reviews oil pollution problems in general terms and recommends action (2) a proposal for "contingency plans" released by the White House in November 1968 and (3,4) summaries of the Oil Pollution Acts of 1924 and 1961.

This booklet can provide historical background data and perspective but is not of great use otherwise.

3. OIL POLLUTION AND THE PUBLIC INTEREST

Authors: A.E. Keir Nash and Dean E. Mann, Dept. of Political Science, University of California - Santa Barbara, and Phil G. Olsen, Dept. of Geology, S ta Barbara City College.

Publisher: Institute of Governmental Studies, University of California, Berkeley (157 pp.; $3.75 ) 1972.

Point of View: "This examination of the Santa Barbara oil spill, and of what the various factors were trying to do, affords an instructive case study of institutional response in a complex new situation". While the authors examine all sides of this complex case it is clear that environmental concerns weigh heavily on them.

Level: Popular

Summary: This is a case study of a very interesting case, the Santa Barbara oil spill which began in late January, 1969. It is of interest in itself as the spill and the damage it caused were spectacular. It is perhaps of more interest in that it provides careful analysis and comment on most of the complicated facets of this case. The one point of view not as clearly presented as the others is that of the oil companies, but one suspects that this slight balance results as much from the inaccessibility of oil company deliberation as from bias on the authors' part.

The report begins with an introduction in which the accident and the reactions to it are briefly described. This is followed by two chapters in which the first two of the "four basic questions" identified by the authors are analysed:

1) What was the state of the Santa Barbara economy?
2) How heavy is the local burden of the spill?
3) Is this only a local situation or does it suggest an area of national concern?
4) Can the kind of conflicts which occured in the Santa Barbara case be resolved within our system?

The answer to the last two of these questions takes up the remaining five chapters of the book. In Chapter IV "Offshore Drilling and the Public Interest" the pro oil company and the arguments against off shore drilling are both presented and the components of a brief risk benefit analysis are assembled.

In Chapter V "Administering Offshore Oil: A Study in Divided Responsibility" the state and federal responsibilities are examined for their effectiveness jointly and separately.

Chapter VI, "Executive and Legislative Remedies: Federal and State" could form the core of a semester's study of government action as it presents not only a chronological summary of the actions by the executive and legislative branches but some analysis of the reasons for and the effects of these actions.

The next chapter, "Legal Remedies" is not historical in the same sense, since most of the Santa Barbara cases have not yet come to court. (The only exception is a case against Union Oil brought by the City of Santa Barbara. It was tried by a retired Judge, brought back into service for this case, who found Union Oil guilty on 1 of 354 charges brought against them, fined them $500 and dropped the other charges). In this chapter the history of environmental cases is briefly explored, the possible "roads to redress" described and results anticipated.

The final chapter, VIII "Where Do We Go From Here: The Ecology, the Economy, and the American Political Future" is not quite as broad as the title indicates. It sets the Santa Barbara controversy in the larger context of the clash between the explor ative and conservative approach to the environment and hypothesizes possible "pro oil" and "pro Santa Barbara" outcomes in each of the three. The authors conclude:

> To sum up, it is too early to conclude that Santa Barbara will in this case prevail over the awesome power of the oil industry. Yet it is also too early to conclude that in the foreseeable future the balance between competing values and interests will remain where they have characteristically been since the New Deal. The importance of the Santa Barbara oil spill and its local aftermath lies not in its representing a last turning point for reevaluating priorities, but rather in its clear illumination in the public limelight of the emerging political competition between old and new economic and ecological lifestyles.

# APPENDICES

Appendix A

Suggested Student Reading

1. WATER SCIENCE AND TECHNOLOGY

Author: T. H. Y. Tebbutt, Department of Civil Engineering, University of Birmingham.

Publisher: New York, Barnes & Noble Books (a division of Harper & Row, Inc.) 1973 (~200 pp; $7.50).

Point of View: "This book aims to give a brief account of current practice in water supply and treatment and wastewater collection and treatment. It is intended as an introduction to the subject for the layman."

Level: Non-technical; illustrated; several tables & graphs; bibliography.

Summary: This is an excellent introductory text written by a British author for use with a non-technical audience. It is a limited "general" reference, in that it deals exclusively with the science and technology which underlie the monitoring, collection, treatment, distribution, and reclamation of water. It is, however, an essential reference for the beginning student of water science and provides a concise, well-illustrated summary of the major concepts and techniques necessary to the understanding of water management.

The introductory chapter briefly notes the unique properties and life-support qualities of water, tracing its importance to civilization back through history. Chapter 2 examines the "Nature and Occurrence of Water" and provides descriptive material on its physical, chemical, and biological characteristics. Brief but useful definitions of such terms as hardness, acidity, pH, BOD, etc., are provided along with a general outline of the kind of biota found in water and a discussion of the complex mechanism of the hydrological cycle. Water use, collection and treatment are the topics of the next three chapters which, again, provide many useful illustrations

Suggested Student Reading (cont'd.)

to supplement the text. The needs of the domestic water supply are contrasted with those of the industrial sector and the various hydrological measurements employed in the collection of water are noted. Several sources of water - reservoirs, river obstruction, and ground water - are examined separately. With this background established, Tebbutt moves on in Chapter 5 to the subject of Water Treatment, providing a brief discussion of the nature of impurities and a fairly developed description of the various stages of conventional water treatment (coagulation, sedimentation, filtration, disinfection, and softening) and specialized treatment processes (removal of tastes and odours, iron and manganese removal, fluoridation and corrosion control). The distribution and collection of water are dealt with in the two following chapters and, again, the discussion is directed to the basic engineering considerations which determine decisions in these areas. Specific topics considered include valves and pumps, surge prevention, corrosion, service reservoirs and water towers, prevention of leakage and waste, sewer design, and surfacewater drainage.

All of these early chapters serve as introduction to the consideration of water pollution, wastewater treatment, and water reclamation which is the major focus of the remainder of the book. It is in these chapters that Tebbutt explores the mechanisms of oxygen balance, toxic materials, and eutrophication. The specific steps involved in sewage treatment are outlined and illustrated and particular attention is paid to the important problems of sludge treatment and disposal. The final technical chapter, Water Reclamation, looks at the problems involved in the re-use of surfacewaters and at the potential of obtaining fresh water from the sea through various processes including distillation, electrodialysis, reverse osmosis, and freezing. Very brief concluding chapters are addressed to the economic and legal aspects of water management and at the research and development

Suggested Student Reading (cont'd.)

issues of the coming decades. While these two final chapters are, at best, cursory treatment of complex issues, the technical material contained in the earlier chapters is extremely well presented. This is surely among the best efforts in print to introduce the non-specialist to the complexities of water science and technology.

2. WATER QUALITY IN A STRESSED ENVIRONMENT

Author: Edited by Wayne A. Pettyjohn, The Ohio State University.

Publisher: Burgess Publishing Company, Minneapolis, Minnesota (309 pp.; $4.95) 1972.

Point of View: "Water pollution has received wide coverage in news media, magazines, and books in the past several years, but it is difficult to obtain reports that either adequately describe specific examples of pollution or provide background geologic or hydrologic information. These readings are intended to fill this need."

Level: "This book can be used as supplementary reading material for students in geology, hydrology, engineering, and perhaps social studies and law, as well as in newly emerging environmental courses."

Summary: This is an excellent collection of readings, providing discussion of some interesting examples of water pollution problems and a very informative and readible introduction to various topics in geology and hydrology. For the most part, the papers are descriptive and non-technical, with data confined to presentation in easy to read tables and graphs. A number of the papers are reprints of government documents, mostly from the U. S. Geological Survey and the Federal Water Pollution Control Association. Others have appeared previously in various specialized journals.

Suggested Student Reading (cont'd.)

Part One, "The Water We Drink", includes three very useful background papers: "Significance of the National Community Water Supply Demand Study"; "Water Quality Criteris - Public Water Supplies"; and "Constituents and Properties of Water", a 1968 U. S. Geological Survey Circular.

Part Two, "Sources of Surface-Water Pollution" is primarily concerned with industrial wastewaters rather than with pollution from municipal sources. Discussions included here focus on three aspects of industrial-related pollution: coal-mine drainage, agricultural wastes, and the special case of the pollution of Lake Erie.

Some fairly sophisticated geological and hydrological background material is provided in Part Three, "Geologic Controls and Ground-Water Pollution", with some especially useful insight into the relationship between solid waste disposal and ground-water contamination. Examples of specific ground-water contamination incidents are provided in Part Four, with separate treatments provided of chromium contamination in Michigan, the role of oil field brines in the pollution of Ohio's waters, problems with sewage legaoons in the state of Washington, and several examples of specific health related water pollution incidents. The special case of trace elements in water pollution is considered in two semi-technical papers in Part Five, "Reconnaissance of Selected Minor Elements in Surface Waters of the U.S." and "A Geologist Looks at Pollution: Mineral Variety". A very good paper on current knowledge as to the extent and impact of trace element contamination.

A final section, "Water Pollution and Legal Controls", contains three papers: "legal Approaches to Water Rights", "Enforcement of 1899 Refuse Act Through Citizen Action" and "Our Water and Wetlands: How the Corps

of Engineers Can Help Prevent Their Destruction and Pollution".

3. TOWARD A CLEANER AQUATIC ENVIRONMENT

Author: Kenneth M. Mackenthun, Director, Technical Support Staff, U. S. Environmental Protection Agency, Office of Air and Water Programs.

Publisher: USGPO, Washington, D. C. (Stock Number 5501-00573; 273 pp.; $2.05) 1973.

Point of View: "This book was prepared to provoke concern for the control of water pollution and to serve as a guide in the investigation and definition of problems associated with the aquatic environment. It has been written principally for use in the curriculum for the upper grades in high schools and in colleges. Hopefully, ... it will be found of value by the aquatic biologists inexperienced in field investigative activities, as well as by sanitary engineers, chemists, attorneys, water pollution control administrators and others who may have need to broaden their understanding of investigative techniques and water quality and technical problems encountered in such studies."

Level: Non-technical; extensive illustration; several tables and figures; technical appendices.

Summary: This is in many ways a useful introductory text for the study of fresh water pollution. The primary focus is on providing a field handbook which would enable the investigator to plan the study of a body of water, to survey the quality of the water under investigation, to report and identify the various nuisances involved (slime, plants, animals, etc.) and to present his findings and conclusions in a uniform, professional manner. By far the bulk of the chapters are directed to this kind of

Suggested Student Reading (cont'd.)

investigative methodology, but there is some introductory materials which provides general observations on the problems of maintaining environmental quality and on the laws and policies which operate as constraints to environmental abuse. Additional material of this kind is included in the final chapter, "Federal Programs for Pollution Abatement and Control" which very briefly surveys the legislative authority behind selected control programs. The author's preface makes clear his primary concern in selecting material for inclusion in the book:

> This book is divided into 21 chapters that address: characteristics of the aquatic environment, insults on the aquatic environment perpertrated by man, controls for such insults, constraints on governmental actions, investigations of aquatic problems, reporting the investigative results, biological nuisances, health-related aquatic problems, keys to common algae and rooted aquatic vegetation, and government abatement and control programs. Investigative techniques are described in detail for the pond, stream, and lake environments, and for special studies. The ability to present a clear, understandable concept of the results of a field investigation by different methods of data display is evaluated. Methods of correcting the causes of slime, plant and animal nuisances are discussed.

It is, in short, the kind of handbook which should prove invaluable to the beginning limnology student. There are superb illustrations throughout the text, and the appendices include some useful mathematical tables and notations, a glossary of technical terms, and a collection of

suggested references for further reading.

4. ENVIRONMENTAL POLLUTION

Author: Laurent Hodges, Department of Physics, Iowa State University.

Publisher: Holt, Rinehart and Winston, Inc., New York (370 pp.; $ 7.95 ) 1973.

Point of View: "This book has been written to fill the need for a one-volume scientific discussion of the major environmental topics - air, water, noise, solid waste, thermal, and radiation pollution - and their effects on man and on the environment."

Level: Semi-technical; numerous tables and graphs; chapter references.

Summary: Designed as a text for an undergraduate course on the Physics and Chemistry of Pollution, this discussion of environmental problems has several factors to recommend it. Most importantly, Hodges has produced here a text which is both informative and readable, combining clear, concise text description with an excellent selection of data in easy to read formats and extensive, carefully chosen recommendations for further reading at the end of each chapter.

Two of the three chapters on water pollution are especially appropriate to this packet" "Water Pollution: Introduction" (Chapter 8, pp. 125-140) and "Water Pollution: Municipal" (Chapter 9, pp. 140-162). In the first of these, Hodges provides discussion of four main topics: The Earth's Water Balance, Water Pollutants, Sources of Water Pollution, and The Costs of Water Pollution. Throughout the introductory material, Hodges demonstrates his thorough acquaintence with the literature and a well developed pedagogical style. The same is true of the chapter on municipal water pollution which follows. Topics covered here include Municipal Water Supplies,

Municipal Sewers and Sewage, Composition and Treatment of Domestic Sewage, Primary Treatment, Secondary Treatment, Advanced Waste Treatment Methods, and Detergents. Although necessarily brief, the treatment of water pollution topics here is uniformly interesting and authoratative.

5. ENVIRONMENTAL CHEMISTRY: AIR AND WATER POLLUTION

Authors: H. Stephen Stoker and Spencer L. Seager, Department of Chemistry, Weber State College.

Publisher: Scott, Foresman and Company, Glenville, Illinois (186 pp.; $3.50) 1972.

Point of View: "We have attempted to stand back and take an objective look at the problems of air and water pollution. Our main focus has been on the chemistry and chemical compounds involved, but some overlap into other scientific disciplines was unavoidable."

Level" Undergraduate text; numerous graphs and illustrations; lists of suggested readings for each chapter provided.

Summary: Again, water pollution is but one topic treated in this text, but in this case the treatment comprises half of the book (pp. 90-178) and is written in a fairly straightforward, textbook style. The intent here is to provide the student with a good, basic grounding in water pollution fundamentals and the authors concentrate on concise explanations accompanied by data in tables and graphs. The entire discussion is focused around seven topics: Water Pollution - General Considerations; Mercury; Lead; Detergents; Synthetic Organic Insecticides; Oil; and Waste Water Treatment. Although less comprehensive than some of the references reviewed here, this is an impressive summary and one that should be extremely useful to

students seeking a brief introduction to water pollution science and technology. A particularly valuable feature of this text is the extensive listings of additional readings appended to each chapter, with particular attention to government documents.

6. ENVIRONMENT AND MAN

Author: Richard H. Wagner, Assistant Professor of Botany, The Pennsylvania State University.

Publisher: W. W. Norton and Company, New York (528 pp.; $7.95) 1974 (Second Edition).

Point of View: "Because of our sudden awareness of the magnitude of man-environmental problems, efforts have been made on many compuses to fill this curriculum gap with courses that recognize man's tremendous impact on the natural world and analyze it from various points of view. Although there were scores of books covering the many individual aspects of the man-environment field, as well as symposia, anthologies and expose's, there were no balanced texts that pulled all the threads together. The first edition of this book was written to fill that need."

Level: Non-technical; illustrated; several diagrams, graphs and tables; Chapter references.

Summary: Designed as a text for the undergraduate general biology course, this book's first edition achieved wide popularity. Two chapters are especially appropriate to this pocket: "Water, Water, Everywhere ..." (Chapter 5, pp. 83-97) and "...Nor Any Drop to Drink" (Chapter 6, pp. 98-132).

The introductory material in Chapter 5 is focused on descriptions of the hydrologic Cycle, Desalination (particularly well-illustrated) and

Weather Control, a brief but interesting account of cloud seeding. Chapter 6 builds on this background, providing a fairly detailed accounting of the categories of Water Pollutants (Saline Waters, Acid Wastes, Organic Wastes, The Human Factor, Animal Wastes, and Wastewater Treatment), Eutrophication, and Thermal Pollution. Again, this is not a very detailed discussion, but it does provide a useful introduction from the point of view of a biologist and is uniformly well illustrated with photographs, diagrams, and easy-to-read graphs and tables.

### 7. MAN'S IMPACT ON ENVIRONMENT

Author: Thomas R. Detwyler, Department of Geography, University of Michigan.

Publisher: McGraw-Hill Book Company, New York (731 pp.; $6.95) 1971.

Point of View: "Man's Impact on Environment substantiates the wide spectrum of environmental changes brought by man, focusing on major processes of change, immediate and extended effects on the environment, and trends in time and space of processes and effects. Taken together, and put into context by synthesizing editorial comments, these articles provide a meaningful overview of the present quality of man's environment and the causes for this condition."

Level: Non-technical; illustrated; chapter references.

Summary: One of several environmental readers published in the early seventies, this collection provides an interesting selection of articles on various aspects of water pollution. Nine articles are included under the topic "Man's Impact on the Waters" (Chapter Four, pp. 15-24) and several of them bear on the municipal wastewater pollution aspect of the problem.

"The Limited War on Water Pollution", by Gene Bylinsky leads off the section with a discussion of pre-1970 water policies and their administration. A critique of current wastewater treatment processes is included and Bylinsky concludes with some recommendations for better administration and funding of water programs.

"The Hydrologic Effects of Urban Land Use" by Luna B. Leopold follows. Originally published in a 1968 U. S. Geological Survey Circular, this brief essay has become something of a classic in the water pollution literature. A list of references is included, although most of them seen overly specified for the general reader and many of them are now a bit dated.

"Thermal Pollution," the reprint of a 1969 Bioscience article by Cornell biologist Lamont C. Cole, provides a brief but informative discussion of the impact of electrical power generation on water quality.

A useful summary of the kinds of manmade pollutants that impact on water is provided in "Manmade Contamination Hazards to Ground Water" by P. H. Mcqauley. Topics briefly treated here include waste from human life processes, organic and inorganic particles, microorganisms, chemical produces of biodegradation, dissolved chemicals of industrial and commercial origin and teachings from solid waste fills.

Although now somewhat dated (1965) Alfred M. Becton's article, "Eutrophication of the St. Lawrence Great Lakes" provides an interesting and fairly detailed accounting of the chemical changes that have taken place in those waters. The four remaining articles in this section, while interesting reading, are really not directly appropriate to the topic of municipal wastewater pollution: "Aquatic Weeds" by Holm, Weldon and Blackburn;

"The Role of Man in Estuarien Processes", by L. Eugene Cronin; "Oil Pollution of the Ocean," by Max Blumer; and "Soviet Plans to Reverse the Flow of Rivers", by Philip P. Micklin.

8. WATER - A PRIMER

Author: Luna B. Leopold, Professor of Geology, University of California, Berkeley.

Publisher: W. H. Freeman and Company, San Francisco (172 pp.; $4.95) 1974.

Point of View: "This short book is designed to cover the general principles of hydrology and the facts concerning water use that must precede any consideration of the impact on the environment of man's use of the water resources."

Level: Semi-technical; illustrated; numerous graphs and tables.

Summary: An updated and expanded version of the well known U. S. Geological Survey publication, "A Primer on Water", this text provides an excellent introduction to various topics in hydrology and water supplies and water use. While there is an impressive amount of quantatative detail here, the text discussion is extremely readable and assumes very little familiarity with water science and technology.

Designed for use as a supplementary textbook in undergraduate courses in earth sciences and environmental studies, the text is accompanied by numerous drawings and illustrations and deals briefly with a limited, though fundamental, selection of topics. In Section I, "Hydrology" topics include the following: Precipitation, Surface Water and Ground Water, Surface Runoff and Storage, The Drainage Network, Flow Frequency and Floods, The Flood Plain and the Channel, The Load of Rivers, and Soil; Plants and Water. In Part II, "Water Supplies and Water Use", Leopold addresses three

Suggested Student Reading (cont.d)

major topics: "The Water in the World," "The Water Budget," and "Amount of Water Available and Its Present Use". A short glossary is appended.

9. WATER WASTELAND

Authors: David Zwick and Marcy Benstock, Ralph Nader's Study Group on Water Pollution.

Publisher: Bantam Books, New York (494 pp.; $1.50) 1972.

Point of View: "Our report is uncompromising, and often harsh, in the judgments it makes. But we believe it is fair. It is our hope that it will help clean up the water and add generally to sound public policies."

Level: Non-technical.

Summary: This is one of the series of reports prepared by the students and professionals who staff Ralph Nader's Study Groups. For the most part, this is an examination of Federal policy in the area of water pollution and most of the chapters here examine one or another aspect of governmental regulation of water use. In Part One "The Danger," Zwick briefly examines the crucial role which water plays in our lives and notes some of the problems which are already too much in evidence.

"Polluters and Protectors", Part Two, provides a general discussion of municipal and industrial pollution, a look at the Federal Water Pollution Control Program, and an examination of the specific problems associated with detergents and with non-point sources of pollution.

In Part Three, "Politics, Action and Inaction" a critique is provided of the interactions between the public, industry, and government in various water issues. Specialized examples of abuse are cited and particular attention is focused on Lake Superior's deteriorating

Suggested Student Reading (cont'd.)

water quality and the kinds of politics that have enabled that to happen.

Part Four, "Law and Order", is directed to an examination of the successes and failures of the Federal Water Quality Program. The lack of specific detail in the recommendations for water quality standardards come under stong criticism here, the "cooperative approach" that the government tends to take with industrial polluters. The problem of jurisdiction, local or federal, are examined and shown to be instrumental in defeating efforts to clean up the waters. Separate chapters in this section address the problems of gathering reliable information on polluters and pollutants and, in "Time is Money," the authors point out the advantages to the polluter of delaying abatement efforts as long as possible. The last two chapters here are directed to examination of Federal Water Quality Standards and the implications of The Refuse Act of 1899.

Finally, in "The New Federation", the authors review the problems associated with subsidies and sanctions, the extent of pollution generated by the Federal government itself, and the "uses and abuses of pollution control research." A series of conclusions and recommenations are included in Part Xuc "Redress." Designed to stimulate as well as to inform, this is an angry book, focused on the problems and failures of national water policy, and it is one that is bound to raise as many questions as it answers.

10. WATER FACTS AND FIGURES FOR PLANNER AND MANAGERS

Author: J. H. Feth, U. S. Geological Survey, U. S. Department of the Interior.

Publisher: Geological Survey Circular 601-1. Free on application to the U. S. Geological Survey, Washington, D. C. (30 pp.; no charge) 1973.

Point of View: "This series of reports is intended to show the relevance of water facts to water problems of urban areas and to examine the adequacy of the existing base of water information."

Level: Non-technical; illustrated; numerous graphs and tables.

Summary: This is but one of many Geological Survey publications reporting on the dimensions of the nation's water supplies. It is written for a general audience and provides a very readable and useful discussion of the nature of water and the relationship between current and projected supplies and demand. A separate section is addressed to "Water Data-Units and Equivalents" with particular attention to "this metric business", and to specific quality units, physical (temperature, conductance, pH, turbidity, sediment, powers of ten) Chemical and Biological. Water-quality standards and criteria are briefly explained and a glossary of terms is appended along with a brief list of references. All in all, a very useful report, particularly for students, and one that manages to explain some fairly complex material in a concise, straightforward style.

11. RESTORING THE QUALITY OF OUR ENVIRONMENT

Author: Report of the Environmental Pollution Panel, President's Science Advisory Committee, The White House.

Publisher: Washington, USGPO (317 pp.) November, 1965.

Point of View: "We attempt here to describe the problem [of pollution], to distinguish between what is known and what is not, and to recommend steps necessary to assure the lessening of pollution already about us and to prevent unacceptable environmental deterioration in the future".

Suggested Student Reading (cont'd,)

Level: Semi-technical; Several graphs and tables.

Summary: This is one of the classic references in environmental literature and reports the first attempt at the Federal level to consolidate the evidence of environmental degradation and to suggest policy initiatives aimed at the control and abatement of pollution. It is a good background reference to the whole range of environmental problems, but is particularly useful as an introduction to water pollution and is included here despite a 1965 publishing date.

The report is divided into two sections; a summary section at the beginning which provides an overview of the problem of pollutants in the environment, and a series of appendices which report on specific aspects of the problem in some detail. None of this is of a very technical nature, although some interesting data is provided, particularly in the summary section.

"The Effects of Pollution" is the first topic treated in the summary section and discussion is provided on a variety of health effects, including those of water-borne pollutants, and on effects on other living organisms, impairment of water and soil resources, polluting effects of detergents, deterioration of materials and urban environments, and climatic effects of pollution. This is a very brief treatment of the topic, but it does introduce the areas of major concern, suggest the magnitude of the problem, and distinguish between what is known and what remains to be researched.

The second topic in the summary section, "The Sources of Pollution", looks briefly at municipal and industrial sewage , animal wastes, urban solid wastes, mining wastes, consumer goods wastes, and "unintentional release", meaningful automobile emissions and other by-products of daily activities.

The question of which direction should be taken in formulating a policy of pollution control is then briefly explored and a rather detailed list of recommendations is provided as the third component of the summary section. All three of these topics are covered in about forty pages, which clearly means that a lot has been glossed over here, but on the whole it is a very concise and useful introduction to the problems of environmental pollution.

Of the ten appendices which make up the bulk of the report, three deal specifically with water pollution issues: "Water Quality", which reviews water pollution and human disease, disposal of waste heat, increases in salinity, and chemical pollutants; "Effects of Chlorinating Wastes", which simply notes that it is a process to be monitored, although no delitorious effects have yet been noted; and "Aquatic Blooms", which introduces the problem of eutrophication. Again, none of these is a thorough treatment of the individual topic, but they are useful as introductory summaries. Taken as a whole, this volume does provide an excellent overview of environmental pollution and should aid the layman reader in putting water pollution in the appropriate overall context.

12. ENVIRONMENTAL QUALITY AND WATER DEVELOPMENT

Author: Edited by Charles R. Goldman, James McEvoy III, and Peter J. Richerson, University of California, Davis.

Publisher: San Francisco: W. H. Freeman and Company (510 pp.; $17.50 ) 1973.

Point of View: "Our study attempts to evaluate the causes of conflict between environmental quality and the development of the nation's water resources and to suggest some possible solutions. We have described the attitudes and values of Americans toward their environment; attitudes

Suggested Student Reading (cont'd.)

and values that have caused us to define environmental quality in different terms during different periods in the past. The report upon which this volume is based attempts to identify basic principles that are necessary for more realistic environmental planning and decision-making..."

Level: Non-technical; illustrated; numerous tables; chapter bibliographies.

Summary: There's a little bit of everything in here, from poetry and descriptions of fluvial civilizations to essays on the psychology of environmentalists, the demographic effects of water development, the status of the Great Lakes, and the controversy surrounding the citing of the Bodega Head nuclear power plant. All in all, it makes for delightful and informative reading in a format that encourages the kind of pick-and-choose approach to topics which has had great success with student and general readers alike. Unlike so many of the "environmental readers" which have appeared in the past few years, the essays here are uniformly of high quality, with a good density of information and careful attention to documentation and style.

While the overall organization seems fairly free-form, there is a progression from general, introductory kind of information to the specific examination of issues, leading into a fair number of case studies, and concluding with a critique of the proposals set forth by the Water Resources Council. It is a big book, not one likely to be read all at once or even completely through in a semester or so, but one senses that this was never the intended purpose. What it does provide, and with a quality unique to the literature, is a readable, broad based source book which should serve a variety of audiences well. For the general reader, it may be sufficient to browse through the introductory essays and then pick a case study or two

to examine in more detail. For the high school or undergraduate college student, there is a wealth of "project" type information here which could well get him started on an exploration of a particular water controversy. For the urban planner or civil engineer, there are several policy and planning essays which should both inform in a general way and stimulate further reading. In short, this is a reference which should be available as a sort of source book on the water environment and man's interaction with it. The underlying theme here is noted in the preface: "to evaluate the causes of conflict between environmental quality and the development of the nation's water resources." It is, of course, a crucial issue and the authors of this volume have done an excellent job of informing the reader, both in the dimensions of the problem and the potential for solution. From the specific recommendations of the editors (all of whom were involved in the National Water Commission study which underlies this book) which are provided in Chapter 1, to the concluding chapter, which critiques the Water Resources Council's proposed principles and standards for planning water and related land resources, there are consistently good essays which should appeal to a broad range of readers.

13. ENVIRONMENTAL QUALITY

Author: Fourth Annual Report of The Council on Environmental Quality.

Publisher: USGPO, Washington, D. C. (499 pp.; $4.30; Stock #4111-00020) 1973.

Point of View: "The Fourth Annual Report of the Council on Environmental Quality was prepared in accordance with the National Environmental Policy Act of 1969, Public Law 91-190, 42 U. S. C. 4321, which requires the Council to report at least once a year on the state of the environment and efforts to improve it."

Suggested Student Reading (cont'd.)

Level: Non-technical; illustrated; numerous graphs and tables.

Summary: Each year the Council on Environmental Quality gathers together the results of its on-going monitoring of the environment and publishes its data and observations in the form of an annual report. These are uniformly well written and infomative and provide an excellent single source reference on all aspects of man's impact on the environment.

This fourth edition of that report provides some excellent data and summary descriptions which are particularly useful as background to the study of water pollution. The report opens with a consideration of "The Urban Environment - Toward Livable Cities", an interesting chapter which examines the concepts of downtown vitality and the function of the neighborhood. Of more relevence to this packet, however, is the case study report, "Cleaning up the Willamette", which is the subject of Chapter 2. The reclamation of this Oregon river, which was once one of the nation's most polluted rivers, has become an inspiration to many state legislatures and is put forward as a model in many discussions of the potential for reclaiming our nation's waterways.

A broader discussion of the whole range of environmental problems is begun in Chapter 3, "Economics and Environmental Management". Damage, avoidance and transaction costs are examined in terms of the past record and the estimates of future expenditures. Separate sections are directed to the discussion of individual pollution problems including, of course, water pollution. Some brief comments are also included on financing methods and on the making and implementation of control policies.

"The Law and Land Use Regulation" is treated in Chapter 4 and, while there is some mention of the Wetlands problem, this is mainly an outline

of overall judicial trends in terms of their response to various environmental concerns. The final section here looks briefly at several approaches common to environmental litigation, including the concepts of economic loss as a "test for taking", the undermining of the diminution of value theory, the nuisance abatement theory, etc.

Specific aspects of the law as it applies in water quality cases are examined in the following chapter, "Perspectives on Environmental Quality". There are separate treatments here of air quality, hazardous pollutants, noise, solid wastes, energy, and land use, along with a twelve-page summation of the water quality situation. Brief summations are provided on the provisions of P. L. 92-50 and on the factors which shaped that law. The prospects of a stronger federal role are examined, and specific discussions are directed to the issues of lake eutrophication, safe drinking water, and protection of the oceans.

Some of the monitoring efforts which underlie these programs are explored in Chapter 6, "Environmental Status and Trends", and the water pollution section here deals in some detail with a description of the National Stream Quality Accounting Network, the EPA studies of water status and trends, the problems of pollution in the Great Lakes, and the results of various, individual efforts to define water pollution status and trends. These latter efforts include the EPA Eutrophication Study, the Water Quality Index, Refinement of Enviro Control Study, and several recent studies of ocean pollution.

Finally, the two concluding chapters, "International Action to Protect the Environment" and "The Citizen's Role in Environmental Improvement", provide some interesting historical data along with an overview of the nature

and the extent of the pollution clean-up effort here and around the world. All in all, it is a useful background document, especially suitable for general and student readers.

APPENDIX B

## Textbooks and Handbooks

### I. General

Fresh Water Pollution, 3 volumes (New York: MSS Information Corp) 1973.

Manual on Water, American Society for Testing and Materials (Phila.: ASTM) 1966.

Water: A Comprehensive Treatise, Felix Franks (New York: Plenum Press) 1971.

Water and Its Impurities, Thomas R. Camp and Robert L. Meserve (Stroudsburg, Pa.: Dowden, Hutchinson & Ross, Inc.) 1974.

Water and Water Pollution Handbook, Leonard L. Ciaccio (New York: Marcel Dekker) 1971. (Four Volumes).

Water Pollution, Julian McCaull and Janice Crossland (NY: Harcourt, Brace & Janovich) 1974.

Water Pollution: Disposal and Reuse, James E. Zajic (New York: Marcel Dekker) 1971.

Water Supply and Pollution Control, 2nd Edition, John W. Clark, et. al. (Intext) 1971.

### II. Wastewater Analysis & Instrumentation

The Analysis of Organic Pollutants in Water and Waste, Wolfgang Leithe (Ann Arbor: Ann Arbor Science Series) 1973.

Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents, EPA Environmental Monitoring Series (EPA 670/4-73-001) July 1973.

Biological Methods for the Assessment of Water Quality, John Cairns and R.L. Dickson, eds. (Phila.: American Society for Testing and Materials) 1973.

Handbook for Analytical Quality Control in Water and Wastewater Laboratories, National Environmental Research Center, Cincinnati, Ohio (PB-213 884/0) June 1972.

Instrumental Analysis for Water Pollution Control, R. H. Mancy (Ann Arbor: Ann Arbor Science Pubs) 1972.

Mathematics for Water and Wastewater Treatment Plant Operators, (2 vols), Joanne Kirkpatrick (Ann Arbor: Ann Arbor Science Pubs) 1973.

Principles of Water Quality Control, T.H. Y. Trebbitt (New York: Pergamon Press) 1971.

Standard Methods for the Examination of Water and Wastewater, (Chicago: American Public Health Assoc.) 1971.

II. Wastewater Analysis & Instrumentation (cont.)

Water: Examination, Assessment, Conditioning, Chemistry, Bacteriology, Biology, Karl Hoel (New York: DeGruyter) 1972 (three volumes).

Water Quality for Practicing Engineers, W.W. Eckenfelder (New York: Barnes & Nobel) 1970.

III. Biology and Chemistry of Polluted Waters

Biology and Water Pollution Control, C.E. Warren (Phila.: W.B. Saunders) 1971.

The Biology of Polluted Waters, H.B.N. Hynes (Toronto: U. of Toronto Press) 1971.

Biology of Water Pollution, ed. Lowell E. Kenp, et. al, Water Programs Office, U.S. Environmental Protection Agency (PB 216 919).

Chemistry for Sanitary Engineers, 2nd Edition, Clair N. Sawyer and Perry L. McCarty (New York: McGraw-Hill) 1967.

The Ecology of Running Water, H.B.N. Hynes (Toronto: U. of Toronto Press) 1970.

Environmental Chemistry, S.E. Manahan (Willard Grant Press) 1972.

Environmental Chemistry in the Laboratory, D.S. Barnes (Canfield Press) 1973.

Freshwater Pollution: Bacteriological and Chemical Pollution of Fresh Water, Charles W. Hendricks, et.al. (New York: MSS Information Corp.) 1972.

Introduction to Environmental Microbiology, Ralph Mitchell (Englewood Cliffs, N.J.: Prentice Hall) 1974.

A Pratical Guide to Water Quality Studies of Streams, F.W. Kittrell, Federal Water Pollution Control Admin. (Washington: USGPO) 1969.

The Practice of Water Pollution Biology, Kenneth M. Mackenthon, Federal Water Pollution Control Administration (PB 216 116) 1969.

Water and Aqueous Solutions: Introduction to a Molecular Theory, Areeh Ben-Naim (New York: Plenum Press) 1973.

Water and Aqueous Solutions: Structure, Thermodynamics and Transport Processes, ed. by R.A. Horne (New York: Wiley Interscience) 1972.

IV. Wastewater Treatment

Application of New Concepts in Physical, Chemical Wastewater Treatment, W.W. Eckenfelder and L.K. Cecil, eds (Elmsford, N.Y.: Pergamon Press) 1972.

Biological Waste Treatment, W.W. Eckenfelder and J.O'Connor (New York: Pergamon Press) 1961.

IV. Wastewater Treatment (cont.)

Design Handbook of Wastewater Systems: Domestic, Industrial, Commercial, Brian L. Goodman (Westport: Techronic Inc.) 1971.

Disposal of Sewage and Other Water Borne Wastes, Karl Imhoff, W.J. Miller and D.K.B. Thistlethwayte (Ann Arbor: Ann Arbor Science Pubs) 1971.

Elements of Water Supply and Wastewater Disposal, G.M. Fain, J.C. Geyer and D.A. Okum (New York: John Wiley) 1971.

Engineering Management of Water Quality, P.H. McGauhey (New York: McGraw-Hill) 1968.

Manual of Wastewater Operations, Texas Utilities Assoc. (Lancaster: Lancaster Press) 1971.

Operation and Control of Water Treatment Processes, Charles R. Cox (Geneva: World Health Organization) 1964.

Physiochemical Processes for Water Quality Control, Walter J. Weber (New York: John Wiley ) 1972.

Practical Waste Treatment and Disposal, Denis Dickinson (New York: Wiley) 1974.

Primer on Wastewater Treatment, U.S. Dept. of Interior, Federal Water Pollution Control Administration (Washington: USGPO) 1969 (PB 213 846).

"Sanitary Sewage" in Our Precarious Habitat, Melvin A. Benarde (New York: W.W. Norton) 1970.

Sewage Treatment, 2nd Ed., Karl Imhoff and Gordon Fair (New York: Wiley) 1956.

Sewage Sludge Treatment 1972, Ronald W. James (Park Ridge, N.J.: Noyes Data Corp.) 1972.

Sewerage and Sewage Treatment, 8th Ed., Harold E. Babbitt (New York: Wiley) 1958.

Treatment and Disposal of Wastewater Sludges, P.A. Visilind (Ann Arbor: Ann Arbor Scinece) 1974.

Wastewater Engineering, Collection, Treatment and Disposal, Metcalf and Eddy (New York: McGraw-Hill) 1972.

Water Quality and Treatment: A Handbook of Public Water Supplies, American Waterworks Association (New York: McGraw-Hill) 1971.

Water Quality Engineering for Practicing Engineers, W.W. Eckenfelder (Cahners) 1970.

Water Supply and Pollution Control, 2nd Ed., J.W. Clark, W. Viessman, Jr. and M.J. Hammer (International Textbook Co.) 1971.

IV. Wastewater Treatment (cont.)

Water Supply Engineering, 6th Ed., Harold E. Babbitt, et. al. (New York: McGraw-Hill) 1962.

Water Supply and Sewerage, 4th Ed., Ernest W. Steel (New York: McGraw Hill) 1960.

Water Supply and Waste Disposal, William A. Hardenergh and Edward B. Rodie (Intext) 1961.

Water Treatment, G.V. James (Cleveland: CRC Press) 1971.

Water Treatment and Examination, W.S. Holden (Longman) 1970.

Water Treatment Handbook, Degremont Company, Editors (Taylor-Carlise) 1973.

Water Supply and Sewerage, Ernest W. Steel, 4th Ed., (New York: McGraw-Hill) 1960.

V. Industrial Wastewaters

Analysis of Industrial Wastewaters, K.H. Mancy and W.J. Weber, Jr. (New York: Wiley Interscience) 1971.

Handbook for Monitoring Industrial Wastewater, U.S. EPA (Washington: USGPO)

Industrial Pollution, N. Irving Sax (New York: Van Nostrand Reinhold) 1974.

Industrial Pollution Control, Keith Tearle, Editor (Cahners) 1973.

Industrial Pollution Control Handbook, Herbert F. Fund, Ed. (New York: McGraw Hill) 1971.

Industrial Waste: Its Handling, Disposal and Reuse, A.W. Neal (Cahners) 1971.

Industrial Waste Manual, Clifford N. Stutz (Brigham) 1972.

Industrial Waste Treatment, Edmond B. Besseliere (New York: McGraw-Hill) 1952.

Industrial Waste Disposal, B. Koziorowski (New York: Pergamon Press) 1972.

Industrial Waste Disposal, R.D. Ross, Editor (New York: Reinhold) 1968.

Industrial Wastes:Their Disposal and Treatment, W. Rudolf, Editor (New York: Reinhold) 1953.

Industrial Wastewater Control, C.F. Gurnham (New York: Academic Press) 1965.

Industrial Water Pollution Control, W. Wesley Eckenfelder, Jr. (New York: McGraw-Hill) 1966.

Manual on Industrial Water and Industrial Waste Water, American Society of Testing and Materials (Philadelphia: ASTM) 1966.

V. Industrial Wastewaters (cont.)

Pollution and Industrial Waste, Barbara Handscher, J. McCod and Henry Enbery (New York: Practicing Law Institute) 1970.

Procedures for Sampling and Measuring Industrial Waste, U.S. EPA (PB 229-321/5).

The Treatment of Industrial Wastes, E.B. Besseliere (New York: McGraw-Hill) 1969.

Waste Disposal Problems in Selected Industries, John E. Ullman, Editor (New York: Hofstra U. Press) 1969.

APPENDIX C

Availability of Government Reports

All of the government reports included here should be available for circulation through the Regional Government Library in your Congressional district. Should you desire to obtain personal copies of these documents, there are five main sources:

1. The United States Government Printing Office. Orders may be sent by mail or, for faster service, phoned in to the Order Desk in Washington. When ordering a document, be sure to give the GPO Stock Number and to include a check or purchase order for the amount required. The Mailing address is:

   Superintendent of Documents
   U. S. Government Printing Office
   Washington, D. C. 20402

   In addition to this main office, there are 12 bookstores located outside of Washington (see last page of this Appendix).

2. National Technical Information Service (NTIS)

   Many of the government reports which used to be available free of charge are now distributed through NTIS. When this is the case with documents referenced here, the NTIS order number is provided along with the price of the document, which is usually $3.00 to $6.00. For NTIS documents, give order number and send check to:

   National Technical Information Service
   Department of Commerce
   5285 Port Royal Road
   Springfield, Virginia 22151

Appendix C (continued)

In addition to the mail-order service provided by the Office of the Superintendent of Documents, Government Printing Office, there are also twelve (12) retail bookstores outside of Washington, D. C. The names and locations of these stores are shown below:

Atlanta Bookstore
Room 100, Federal Building
275 Peachtree Street, NE
Atlanta, Georgia 30303
Telephone: AC 404/526-6947

Birmingham Bookstore
Room 102A, 2121 Building
2121 Eighth Avenue North
Birmingham, Alabama 35203
Telephone: AC 205/325-6056

Boston Bookstore
Room G25, John F. Kennedy Federal Bldg.
Sudbury Street
Boston, Massachusetts 02202
Telephone: AC 617/223-6071

Canton Bookstore
Federal Office Building
201 Cleveland Avenue, SW
Canton, Ohio 44702
Telephone: AC 216/455-4354

Chicago Bookstore
Room 1463 - 14th Place
Everett McKinley Dirksen Building
219 South Dearborn Street
Chicago, Illinois 60604
Telephone: AC 214/749-1541

Dallas Bookstore
Room IC46
Federal Building - U. S. Courthouse
Dallas, Texas 75202
Telephone: AC 214/749-1541

Denver Bookstore
Room 1421
Federal Building - U. S. Courthouse
Denver, Colorado 80202
Telephone: AC 303/837-3965

Kansas City Bookstore
Room 144, Federal Office Building
601 East 12th Street
Kansas City, Missouri 64106
Telephone: AC 816/374-2160

Los Angelos Bookstore
Room 1015, Federal Office Building
300 North Los Angelos Street
Los Angelos, California 90012
Telephone: AC 213/688-5841

New York Bookstore
26 Federal Plaza, Room 110
New York, New York 10007
Telephone: AC 212/264-3826

Pueblo Bookstore
Public Document Distribution Center
Pueblo Industrial Park
Pueblo, Colorado 81001
Telephone: AC 303/544-5277

San Francisco Bookstore
Room 1023, Federal Office Building
450 Golden Gate Avenue
San Francisco, California 94102
Telephone: AC 415/556-6657

Appendix C (continued)

3. Congressional Committees. Several of the hearings documents included here were printed solely for distribution by the Committee concerned and are not available through the GPO. Requests for these documents should be addressed to the Publications Officer of the Committee noted under "author" in the write-up.

4. Your Representative to Congress

Requests for Library of Congress publications must be made by a representative to Congress; there is no public access to these internally produced reports. As a rule, Congressmen are eager to provide constituents with any assistance possible and they frequently are able to provide free copies of Congressional Hearings and background documents. Requests should be made as specifically as possible (publication date, order number, etc.) and you should allow several weeks time for response.